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# Wastewater Alternatives for Small Communities

(U.S.) Municipal Environmental Research Lab.
Cincinnati, OH

Dec 80

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16. ABSTRACT

This report is a compilation of many papers presented at two of EPA's Seminars on Wastewater Alternatives for Small Communities in August 1978. Titles of papers are: On-Site Alternatives; On-Site Systems Residuals; Pressure Sewer Systems; Alternative Sewer Systems and Costs of Alternatives; Small Flows Clearinghouse; Generating and Analyzing Alternatives; Institutional Considerations in Implementing On-Site and Small Community Wastewater Management Programs.

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|---|---|---|
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December 1980

# WASTEWATER ALTERNATIVES FOR SMALL COMMUNITIES

Proceedings of a Seminar Presented to
EPA Regional Coordinators and State Small
Community Systems Coordinators
August, 1978

Edited by
Steven W. Hathaway
Wastewater Research Division
Municipal Environmental Research Laboratory
Cincinnati, Ohio 45268

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MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

## FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and intergrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communication link between the researcher and the user community.

This seminar on wastewater alternatives for small communities was presented specifically for state officials and regional EPA officials involved in review and approval of facilities plans for small community and individual wastewater treatment systems.

Francis T. Mayo, Director
Municipal Environmental Research
Laboratory

## DISCLAIMER

The contents of these Proceedings do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

# ABSTRACT

This seminar on wastewater alternatives for small communities was presented specifically for state officials and regional EPA officials involved in review and approval of facilities plans for small community and individual wastewater treatment systems. The recent emphasis on innovative and alternative technology with respect to funding was a major issue in this conference as well as the technical output from the researchers who presented the alternative technology. The most recent state-of-the-art was presented along with several case histories of small system implementation and management. The proceedings of this conference contains papers presented by EPA and non-EPA experts in both technical and management fields.

# WASTEWATER ALTERNATIVES FOR SMALL COMMUNITIES

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# On-Site Alternatives

by

Richard J. Otis and William C. Boyle
University of Wisconsin

## Subsurface Soil Absorption Systems

Description:

A method used for the disposal of pretreated wastewater via soil percolation with ultimate discharge to the groundwater table. The system consists of a shallow excavated area partially filled with coarse rock. Perforated piping is placed over the rock to distribute the wastewater throughout the system. Loading rates depend on the soil characteristics. The entire system is buried.

Applicability:

Wastewater Influent Characteristics:

Volume: Conventional method for single family dwellings but systems sufficiently large to handle 100,000 gpd are in operation. Size is limited by site conditions only.

Pretreatment: Sedimentation, conventionally provided by septic tanks.

Site Conditions:

Soils/Geology: Deep, well to moderately well drained soils with percolation rates of 1 to 60 minutes/inch (measured by the percolation test). Three feet of unsaturated soil should exist between the infiltrative surface (bottom of system) to the seasonally high water table or bedrock.
Topography: 0 to 25% slopes. Avoid depressions and bases of slopes
Setback Distances: Check local code.

Climatological Conditions: None

Treatment Capability:

$BOD_5$: Nearly complete removal
SS: Nearly complete removal
Nitrogen: Complete nitrification; negligible removal.
Phosphorus: Nearly complete removal except in coarse clean sands.
Pathogenic bacteria: Nearly complete removal.
Virus: Complete removal.

Operation/Maintenance Requirements:

Labor: Negligible
Power: In some cases a lift station may be necessary to dose the system.
Chemicals: None
Residuals: None

Environmental Concerns:

Low energy requirements

Recharge groundwater table

Increase salts concentration in groundwater, particularly nitrates and chlorides

Costs:

Construction: $1.15 - $1.50/ft^2

Operation/Maintenance: -

Comments:

Periodic resting of the system prolongs the life of the system. A resting period can be provided by constructing two beds of equal size which receive wastewater alternately on a 6 to 12 month frequency.

Performance of the system is improved with dosing. This can be provided with a pumping or siphoning unit which doses the field 1 to 4 times daily.

For larger systems, pressure distribution improves performance by uniformly applying effluent over the infiltrative surface.

Source Materials:

Management of Small Waste Flows, pp. B-107 to B-129.

Local septic tank system construction codes.

Otis, R.J., et al., 1978. "Design of Conventional Soil Absorption Trenches and Beds," Home Sewage Treatment, Amer. Soc. Agr. Engr. Publication 5-77. St. Joseph, Michigan.

Otis, R.J., et al., 1978. "Effluent Distribution," Home Sewage Treatment, Amer. Soc. Engr. Publication 5-77. St. Joseph, Michigan.

Parker, D.R., et al., 1978, "Site Evaluation for Soil Absorption Systems," Home Sewage Treatment, Amer. Cos. Agr. Engr. Publication 5-77. St. Joseph, Michigan.

Demonstration Installations:

City of Greenleaf, Idaho

System: Community system serving 20 homes, shops and school. Constructed in 1974.

Source: Southwest District Health Department (Nampa-Caldwell) (208) 459-0744.

Pierce County, Washington

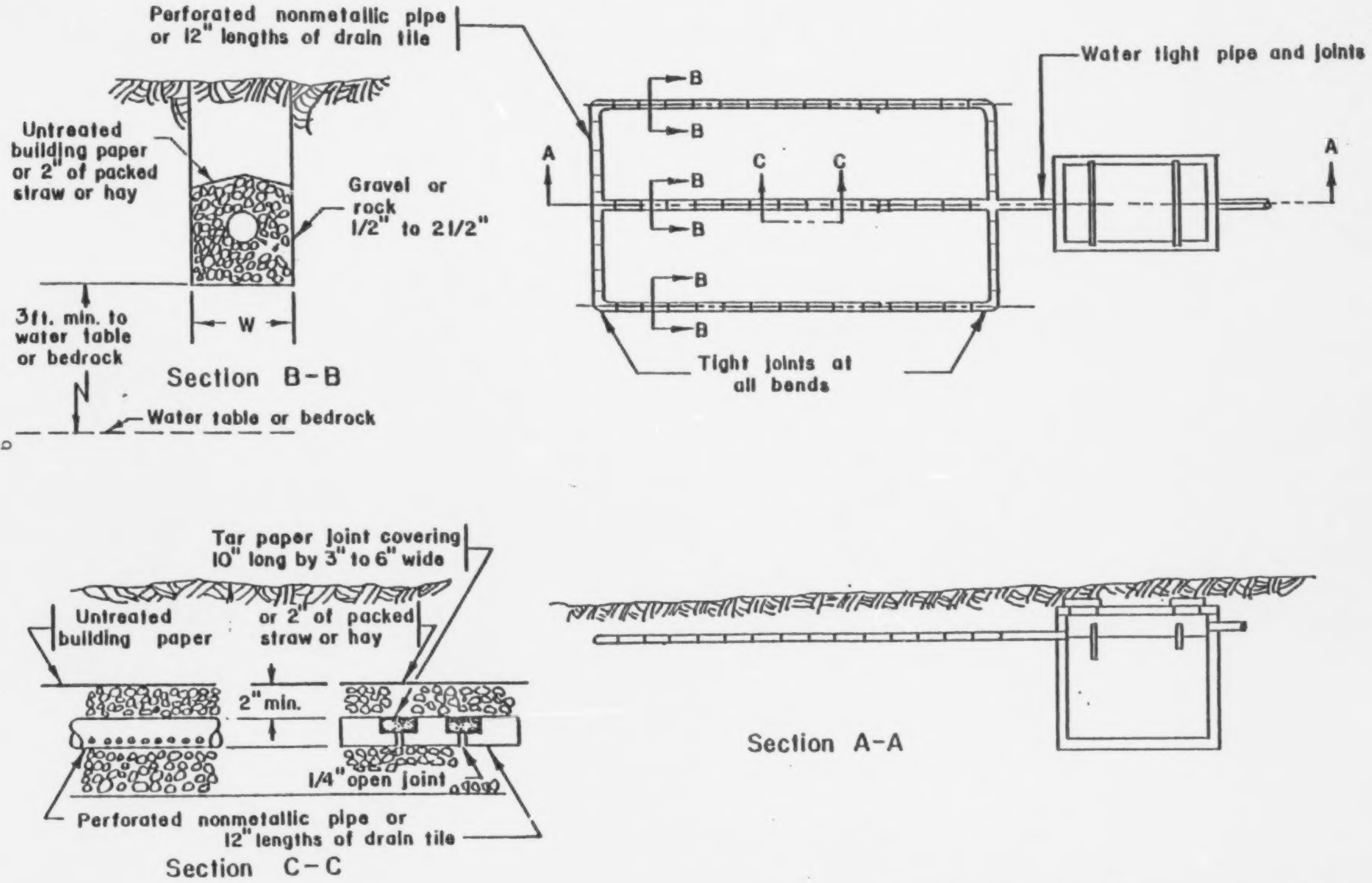
Systems: 127 large systems (10,000 gpd) throughout county including a 200 lot subdivision (60,000 gpd). First system constructed in 1970.

Source: Public Works Department (206) 593-4157

Westboro, Wisconsin

System: Community system designed for 30,000 gpd constructed in 1977.

Source: University of Wisconsin (608) 263-3137


Perforated nonmetallic pipe or 12" lengths of drain tile
Water tight pipe and joints
A
B
C
Tight joints at all bends
Untreated building paper or 2" of packed straw or hay
Gravel or rock 1/2" to 21/2"
3ft. min. to water table or bedrock
W
Section B-B
Water table or bedrock
Tar paper joint covering 10" long by 3" to 6" wide
Untreated building paper
or 2" of packed straw or hay
2" min.
1/4" open joint
Perforated nonmetallic pipe or 12" lengths of drain tile
Section C-C
Section A-A

INDIVIDUAL HOME ABSORPTION SYSTEM

## Mounds

**Description:**

A method used for the disposal of pretreated wastewater via soil percolation on sites where soils are unsuited for subsurface soil absorption systems. The system consists of an elevated sand mound placed over the original soil in which the gravel seepage area is constructed. The sand fill provides additional soil material necessary to adequately treat the waste before it reaches the groundwater at sites with shallow or excessively permeable soils and permits the use of the more permeable natural topsoil at sites with slowly permeable subsoil. Wastewater is dosed into the mound by pump or siphon. Ultimate discharge of the percolate is to the groundwater table.

**Applicability:**

Wastewater Influent Characteristics:

Volume: Size is limited by site conditions only. Principal application has been for single family dwellings, schools and small commercial establishments.

Pretreatment: Sedimentation, conventionally provided by septic tanks.

Site Conditions:

| | Slowly Permeable Soils | Permeable Soils With Shallow Soils | | Permeable Soils With High Water Tables | |
|---|---|---|---|---|---|
| Soils/Geology: | | | | | |
| Topography: | <6% | <12% | <6% | <12% | <6% |
| Percolation Rate (min/in): | 60-120 | 3-29 | 30-60 | 3-29 | 30-60 |
| Depth to Groundwater: | >2 ft | >5 ft | >5 ft | >2 ft | >2 ft |
| Depth to Bedrock: | >5 ft | >2 ft | >2 ft | >5 ft | >5 ft |
| Setback Distances: Check local septic tank codes | | | | | |

Climatological Conditions: None

**Treatment Capability:**

$BOD_5$: Nearly complete removal through sand fill
SS: Nearly complete removal through sand fill
Nitrogen: Complete nitrification; negligible removal through sand fill
Phosphorus: Little removal through sand fill
Pathogenic bacteria: Nearly complete removal through sand fill
Virus: Complete removal through sand fill

Operation/Maintenance Requirements:

Labor: Negligible
Power: In most cases, a pump is necessary to dose the system. Where sufficient head is available, siphons can be used
Chemicals: None
Residuals: None

Environmental Concerns:

Low energy requirements

Recharges groundwater table

Increases salts concentrations in groundwater, particularly nitrates and chlorides

Visual impact of mound may be positive or negative

Costs:

Construction: Costs depend on distance to suitable fill material. Costs may range from $0.75 to $3 per sq.ft. of basal area, including the pumping chamber and controls.

Operation/Maintenance: Pump operation and maintenance

Comments:

Crested or sloping sites are preferred.

Because pressure distribution is used, the mounds can be shaped to fit the lot or landscaping.

Source Materials:

Management of Small Waste Flows, pp. B-141 to B-151.

Converse, J.C., et al., 1978. "Mounds for the Treatment and Disposal of Septic Tank Effluent," Home Sewage Treatment. Amer. Soc. Agr. Engr. Publication 5-77, St. Joseph, Michigan.

Converse, J.C. et al., 1975. "Design and Construction Procedures for Mounds in Slowly Permeable Soils," Small Scale Waste Management Project, 1 Agricultural Hall, University of Wisconsin, Madison.

Converse, J.C., et al., 1975. "Design and Construction Procedures for Fill Systems in Permeable Soils With Shallow Creviced Bedrock." Small Scale Waste Management Project, 1 Agricultural Hall, University of Wisconsin, Madison.

Converse, J.C., et al., 1975. "Design and Construction Procedures for Fill Systems in Permeable Soils With High Water Tables." Small Scale Waste Management Project, 1 Agricultural Hall, University of Wisconsin, Madison.

Demonstration Installations:

Bayview Heights Mobile Home Park, Stoughton, Wisconsin

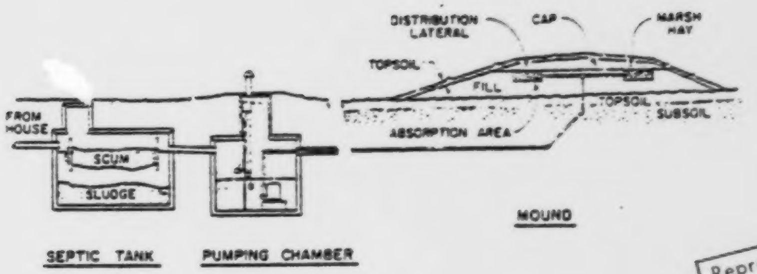
System: Serves 200 mobile homes to be constructed in 1979.
Design flow of 42,000 gpd

Source: Carl C. Crane, Inc., Madison, Wisconsin

Seneca, Wisconsin

System: Community system to serve 60 homes, shops and school to be constructed in 1979.
Design flow of 25,000 gpd

Source: Davy Engineering Co., LaCrosse, Wisconsin


DISTRIBUTION LATERAL
CAP
MARSH HAY
TOPSOIL
FILL
TOPSOIL
SUBSOIL
FROM HOUSE
SCUM
SLUDGE
ABSORPTION AREA
MOUND
SEPTIC TANK
PUMPING CHAMBER

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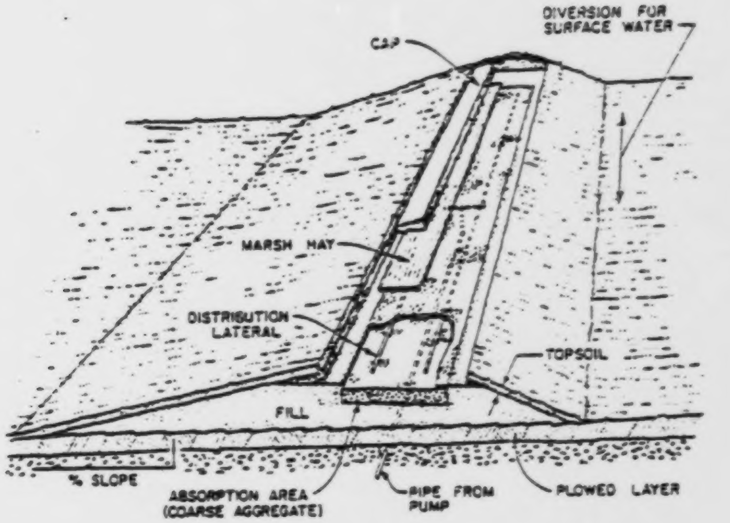
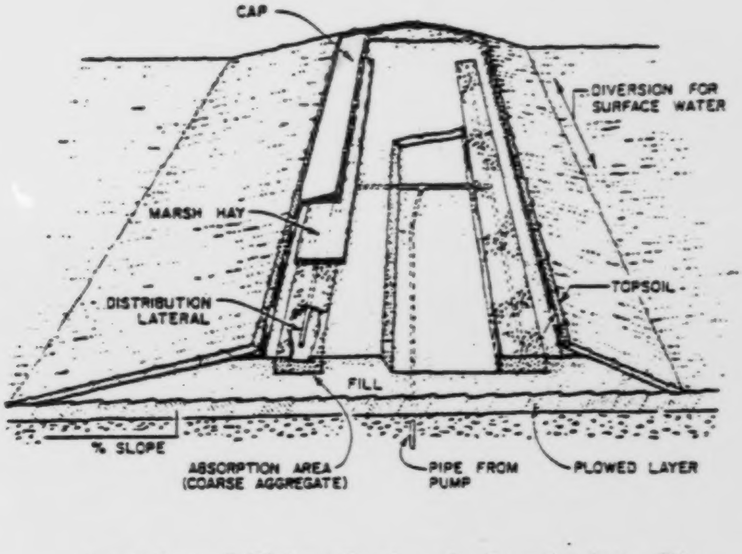

DIVERSION FOR SURFACE WATER
CAP
MARSH HAY
DISTRIBUTION LATERAL
TOPSOIL
FILL
% SLOPE
ABSORPTION AREA (COARSE AGGREGATE)
PIPE FROM PUMP
PLOWED LAYER

A Mound System Utilizing a Bed as the Absorption Area.


CAP
DIVERSION FOR SURFACE WATER
MARSH HAY
DISTRIBUTION LATERAL
TOPSOIL
FILL
% SLOPE
ABSORPTION AREA (COARSE AGGREGATE)
PIPE FROM PUMP
PLOWED LAYER

A Mound System Utilizing A Trench as the Absorption Area. This System is Recommended for Slowly Permeable Soils with High Water Tables.

## Flow Reduction - Water Saving Fixtures/Appliances

Description:

An extensive array of plumbing devices and appliances which have been developed to effectively reduce water consumption. In general, water savings devices or systems may be characterized as reliable or unreliable in yielding projected waste flow reduction depending upon whether the system requires an active or passive role by the consumer. General classification and listing of selected devices and systems appear in Table 1. The integration of these devices or systems in waste treatment and disposal flowsheets are presented in a separate section.

Applicability:

Wastewater Influent Characteristics:

Volume: No requirements

Pretreatment: None required

Site Conditions: No requirements

Climatological Conditions: No requirements

Treatment Capability:

Variable, depending upon device or system. See Table 1.

Operation/Maintenance Requirements:

Variable, see Table 1.

Environmental Concerns:

None

Costs:

Variable, depending upon device. See Table 1.

Source Material:

Small Scale Waste Management Project Final Report, Grant No. R 802874-03, USEPA. Appendix A, Wastewater Characteristics and Treatment, 1978.

Siegrist, R.L., T. Woltanski and L.E. Waldorf, 1977. "Water Conservation and Wastewater Disposal," Proc. of Second National Home Sewage Treatment Symposium, ASAE, Chicago, Illinois.

Washington Suburban Sanitary Commission, 1974. "Final and Comprehensive Report - WSSC Water Conservation/Wastewater Reduction, Customer Education and Behavioral Change Program," WSSC, Hyattsville, Maryland

Milne, M., 1976. "Residential Water Conservation," California Water Resources Center, Report No. 35, University of California, Davis, California.

Wallman, H. and S. Cohen, 1974. "Demonstration of Waste Flow Reduction From Households," USEPA, No. EPA 670/2-74-071.

Table 1

Water Saving Fixtures/Appliances

| Generic Type | Flow[++] Reduction (%) | Wasteload Reduction (Pollutant) | Active/ Passive* | O/M** | Cost Range[***] ($) |
|---|---|---|---|---|---|
| Toilet Devices[+] | | | | | |
| Toilet tank inserts | 15-45 | None | P | | 2-6 |
| Dual flush devices | 15-30 | None | A | | 5-15 |
| Bathroom Devices | | | | | |
| Bathtubs - low volume | 0-30 | None | P | | 0 |
| Shower flow controls | 10-40 | None | A | | 5 |
| Reduced flow shower fixture | 40-80 | None | A | | 1-10 |
| Air-assisted shower system | 60-90 | None | A | | 275-300 |
| Sink faucet restrictions | 30-90 | None | A | | 1-10 |
| Laundry | | | | | |
| Suds savers | 10-30 | BOD, P, SS | A | | 15-30 |
| Multilevel cycle control | 10-40 | None | A | | 50-75 |
| Kitchen | | | | | |
| Multicycle control dishwasher | 10-40 | None | A | | 50-9 |
| Garbage disposal elimination | 95 | BOD, P, N, FOG | P | | - |
| Sink faucet restrictors | 30-90 | None | A | | 1-10 |

[+] Does not include toilets which are covered elsewhere.

[*] User role in achieving reduction.

[**] O & M in excess of conventional system (E).

[***] Capital cost in excess of conventional.

[++] Percent reduction in flow rate when flowing wide open, or in volume/use.

## Flow Reduction - Low Flow Water Carriage Toilets

Description:

A number of water carriage toilets have been designed to reduce total flush volume and yet provide sufficient cleansing velocities within the bowl. Two generic types which have proven successful are the shallow trap toilet and the very low volume flush toilet.

Shallow trap toilet - redesigned conventional bowl with modified flushing rim and priming jet to produce a siphonic flushing action in a smaller diameter trapway.

Very low volume flush toilet - conventional in appearance these toilets employ either (1) gravity discharge through a high-slope, relatively short discharge line or (2) a vacuum, compressed air or grinder pump to assist in flushing.

Applicability:

Wastewater Influent Characteristics: No requirements

Climatological Conditions: No requirements

Site Conditions: None required

Treatment Capabilities:

Shallow trap toilet - no pollutant reduction,
flow reduction - 20% (3-3.5 gal/flush)

Very low volume flush toilet - no pollutant reduction,
flow reduction - 70-90% (<1 gal/flush)

Operation/Maintenance Requirements:

Shallow trap toilets - similar to conventional toilet systems

Very low volume toilets -

Labor: Little maintenance is required over and above conventional system; maintenance of compressor, grinder pump or vacuum pump is required. Moderate hardware complexity; holding tank pumping if used.

Power - Low; required for compressor, grinder or vacuum pump (est. ~.01 kwh/flush).

Environmental Concerns:

Energy
Holding tank residuals

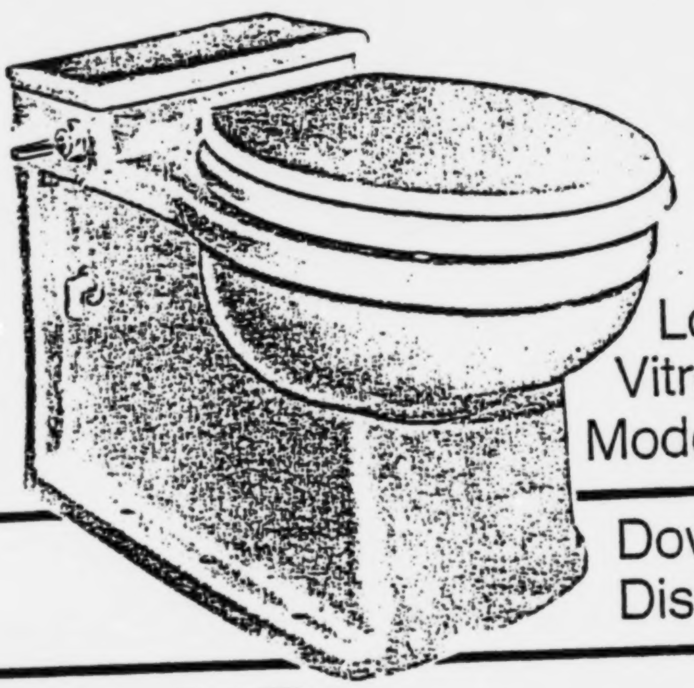
Costs:

Shallow trap toilets - Installed cost: $10-$15 in excess of conventional systems.

O & M: Negligible over and above conventional system.

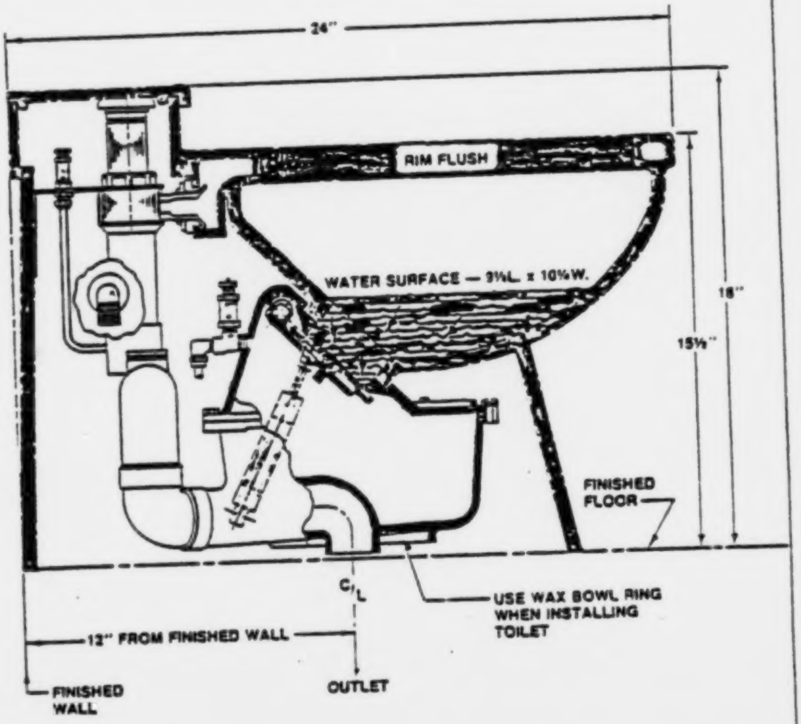
Very low volume toilets - Installed cost: $350-$400 in excess of conventional system.

O & M: $1-$10/yr power and maintenance.



Low Flush Toilet
Vitreous China
Model LF-210

Downward
Discharge


24"
RIM FLUSH
WATER SURFACE — 9¼L. x 10¾W.
18"
15½"
FINISHED FLOOR
C/L
USE WAX BOWL RING WHEN INSTALLING TOILET
12" FROM FINISHED WALL
FINISHED WALL
OUTLET

## Flow Reduction - Incinerating Toilets

Description:

Incinerating toilets are small, self-contained units which utilize the process of incineration to volatilize the organic components of solid wastes and evaporate the liquid. Wastes are deposited directly into a combustion chamber and are incinerated upon a signal. The process is fueled by gas, fuel oil or electricity. In gas units, the combustion/cooling process takes about 20 minutes while electric units require approximately 45 minutes. Units are equipped with appropriate gas vent and blower.

Applicability:

Wastewater Characteristics:

Units are designed for toilet wastes only.

Site Characteristics: None

Climatological: None

Treatment Capability:

The incinerator units convert toilet wastes to ash and gas if properly maintained and operated. Controlled evaluation of performance in households is lacking.

Operation/Maintenance Requirements:

Labor: Removal of ash residue should be provided approximately once per week. Routine cleaning of toilet bowl or replacement of toilet bowl liner is required. Periodic cleaning and alignment of gas burner assembly, adjustment of air/fuel ratio; cleaning spark plug may be required two to four times/year for gas/oil units. Cleaning of heating elements, vent blower and line may require attention two to four times per year.
Power: Gas/Oil: 0.2-0.3 lb. gas/use
Electric: .06-1.2 kwh/use
Chemicals: None
Residuals: Ash

Environmental Concerns:

Noise; odors during incineration cycle; potential fire hazard if improperly installed.

Costs:

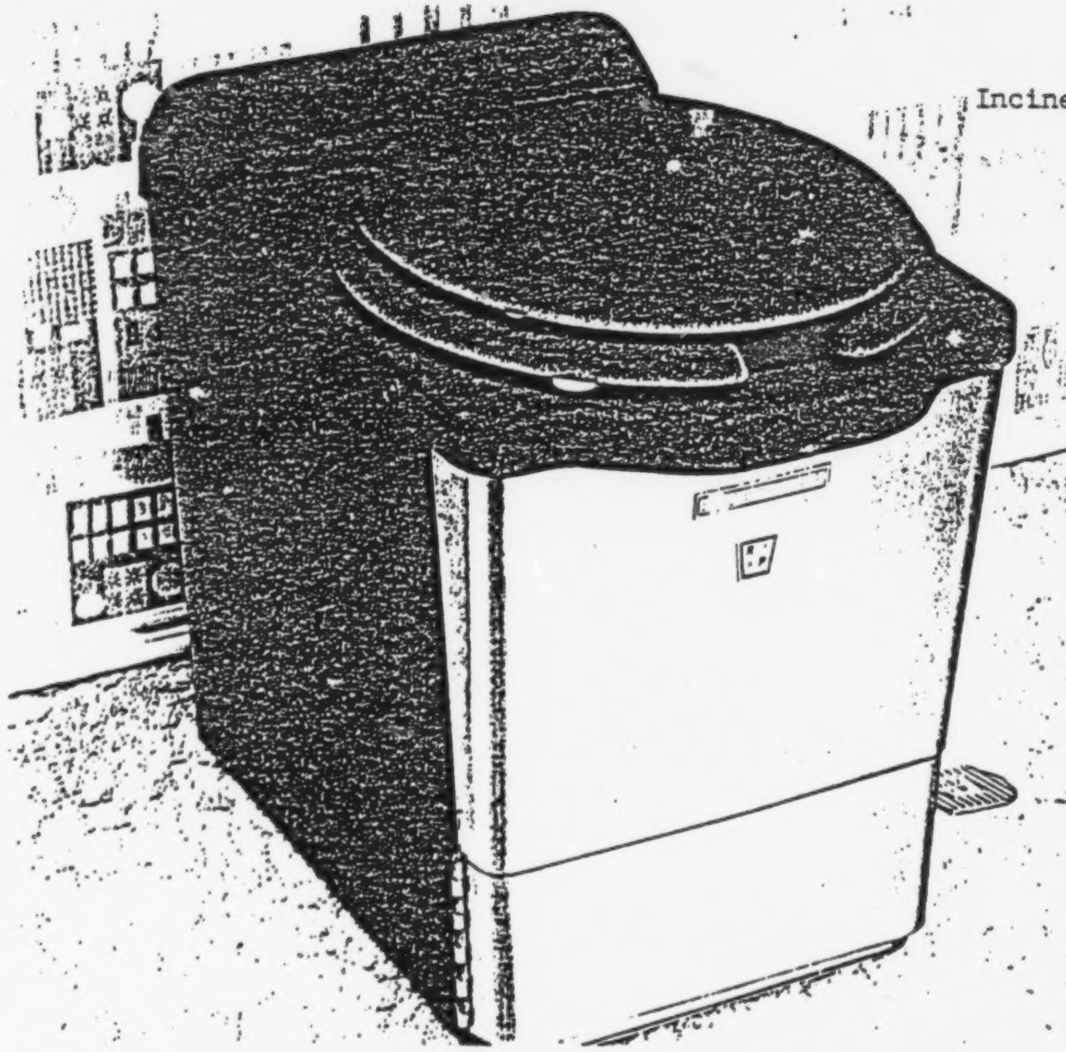
| | Oil/Gas | Electric |
|---|---|---|
| Installed Cost | \$800-\$1200 | \$800-\$1000 |
| Operation/Maintenance | | |
| Power | \$200 | \$300 |
| Labor (8 hr/yr) | \$ 80 | \$ 80 |

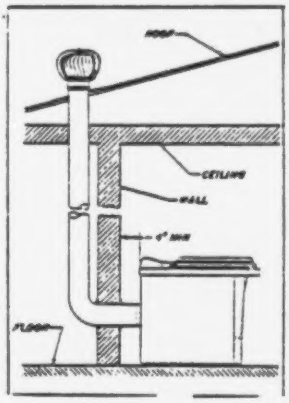
Source Materials:

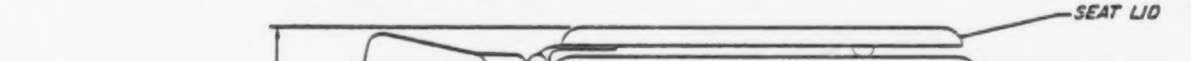
Orr, R.C. and D. W. Smith, 1976. "A Review of Self-Contained Toilet Systems With Emphasis on Recent Developments," Northern Technology Center, Environmental Protection Service, Edmonton, Alberta Canada.

Milne, Murray, 1976. "Residential Water Conservation," California Water Resources Center, Report 35, University of California, Davis, California.

# Incinerating Toilet




ROOF
CEILING
WALL
4" MIN
FLOOR


SEAT LID
SEAT
TOP
FLUSHING BOWL
BLOWER MOTOR
FLUSHING MECHANISM
B
BLOWER WHEEL & HOUSING
INSULATED LID
21 5/8
HEATING ELEMENT
VENT COLLAR
C
INCINERATOR
BLOWER SUPPORT
10 3/4
INSULATION
EMISSION CONTROL SYSTEM
ASH PAN
ODOR REDUCING CATALYST
A
D
INSULATED BOTTOM
TIEDOWN BRACKET (CF ONLY)

SIDE VIEW

## Flow Reduction - Composting Toilets

Description:

Composting toilets are non-water carriage toilets in which organic matter from feces, urine and sometimes garbage undergoes aerobic composting. Two basic varieties of toilet systems are available, those in which the point of use is removed from the decomposition chamber (separated) and those in which the point of use is directly attached to the chamber (non-separated).

The separated units are normally ventilated, large "two-story" units which provide an effective volume of 30 to 70 $ft^3$. These units may require forced ventilation to maintain aerobic conditions and rely on low-rate aerobic biological action. The non-separated units providing a volume of from 2 to 5 $ft^3$, are forced air ventilated and equipped with an electric heating element and a mechanical stirring mechanism. These smaller units depend upon both thermal dehydration and high rate aerobic biological activity.

Applicability:

Wastewater Influent Characteristics:

Volume: Non-separated unit is subject to hydraulic overloads.

Pretreatment: Composting toilets handle toilet wastes and some garbage wastes only.

Site Conditions: None

Climatological Conditions: None

Treatment Capability:

Composting toilets will eliminate the toilet (and garbage) wastes from the household wastewater stream. The treated residue will be a dispersible humus which may be dispersed on the soil (provided the unit is properly operated and maintained). Improper aeration, or excessive build up of water may result in anaerobic conditions and short-circuiting which may produce inadequately treated residue. There is still some concern about the health hazards associated with the dispersible residue; pathogen dieoff under composting is significant and, under proper operation, the humus is relatively pathogen free. No long-term reliability tests are available.

Operation/Maintenance Requirements:

Labor: If composting toilets are to be used and maintained properly, the owner must make a significant commitment to understanding, using and maintaining the system.

Separate units - Removal of compost residue at least once per year; periodic addition of sawdust, etc. to prevent compost mass compaction at least once per month; infrequent maintenance of mechanical parts, and compost mixing is expected.

Non-separated units - Removal of compost residue at least four times per year; mixing of compost daily; infrequent maintenance of mechanical parts including fan, heater and stirrers is expected.

Power: Separated units: 1-1.5 kwhr/d

Non-separated units: 2.5 kwhr/d

Chemicals: Inert "starters" are normally required to maintain good moisture distribution, prevent compaction and facilitate aeration. Added periodically.

Residuals: Residue must be discharged from one to four times per year.

Environmental Concerns:

Fly infestations due to inadequate venting and residue handling

Odor nuisance due to inadquate venting and anaerobic conditions

Health hazards resulting from inadequate pathogen destruction

Fire hazard (?)

Costs:

| | Separated Unit | Non-Separated Unit |
|---|---|---|
| Installed Cost | $2300-$3200 | $900-$1200 |
| Operation/Maintenance | | |
| Power | $15 | $34 |
| Labor | $ 20 (4 man hr/yr) | $ 40 (8 man hr/yr) |

Source Materials:

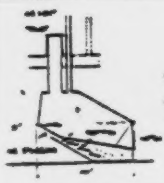
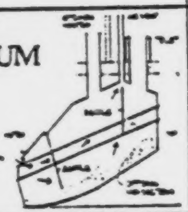
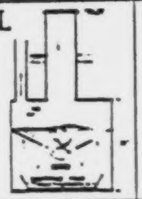
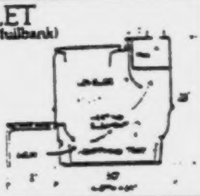
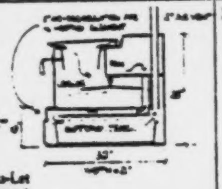
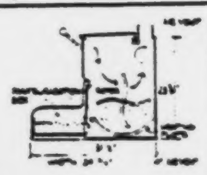
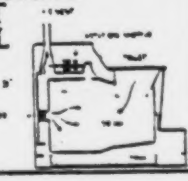
McKernan, J.M. and D.S. Morgan, 1976. "Experiences With the Clivus-Multrum and Mull-Tox Toilets in Northern Manitoba - Interim Report; Manitoba Department of Northern Affairs, Winnipeg.

Guttormsen, D., et al., 1975. "21 Biological Toilets - Decomposition Toilets for Cabins and Holiday Homes," Consumer Report 10, Agricultural College of Norway, Aas, Norway.

Moreau, Eugene, 1977. "Maine's Perspective on Composting Toilets and Alternative Grey Water Systems," Compost Science 18, 4,.

Stoner, C.H., 1977. Goodbye to the Flush Toilet, Rodal Press, Emmaus, Pennsylvania.

# GUIDE TO THE COMPOSTING TOILETS

| TYPE | VOLUME | MATERIAL | PRICE AS OF Feb. 1, 1977 | CAPACITY | ELECTRICAL REQUIREMENTS | FEATURES |
|---|---|---|---|---|---|---|
|  TOA-THRONE | Large volume | Polyethylene<br>SIZE<br>39 × 66 × 51 | $845-$1045 depending on accessories | 4-6 persons; can handle overloads | Optional ventilating fan 110V-20W | Single waste chute insures layering of human & vegetable waste<br>Produces nutrient rich humus<br>No external power source necessary<br>No pasteurization of humus required<br>Ideal for new construction |
| CLIVUS MULTRUM  | Large volume | Fiberglas<br>SIZE<br>45 × 101 × 79 | $1400-$1685 depending on accessories | 6-10 persons depending on number of midsections | Optional ventilating fan 110AC-46W | Produces nutrient rich humus<br>No external power source necessary<br>Insulated model available<br>No pasteurization of humus required<br>Ideal for new construction |
| BIOLOGICAL TOILET MODEL 75 + 75B  | Medium | Fiberglas<br>SIZE<br>36 × 40 × 36 | $1400-$1700 inclusive | 2-4 persons (15 persons with optional evaporator) | 2 fans 110V-46W<br>Rotation motor 110V-180W<br>Heating element 110V-1200W | Automatic mixing of waste to prevent compacting<br>Internal heating elements<br>Produces nutrient rich humus<br>No pasteurization of humus required<br>Ideal for new construction |
| ECOLET (same as Mullbank)  | Small volume | Polystyrene (plastic)<br>SIZE<br>24 × 42 × 32 | $736 inclusive | 3-5 persons with occasional overloads | 110V AC<br>Transformer 110V<br>Fan 42V-21W<br>Heating element 42V-140W | Easy installation<br>Internal heating elements<br>Produces nutrient rich humus<br>No pasteurization of humus required |
|  MULL-TOA (same as Blu-Let or Soddy Potty) | Small volume | Polyethylene (plastic)<br>SIZE<br>21 × 30 × 28 | $795 inclusive | 2-4 persons with occasional overloads | 110V-AC 250W<br>2 fans<br>2 thermo-statically controlled heating elements<br>Automatic leveler | Automatic mixing of waste<br>Built-in hygrometer to indicate humidity<br>Easy installation<br>Greatest weight reduction of waste of comparable models<br>Lowest volume of air evacuated of comparable models (9 liters per second)<br>Internal Heating elements<br>Produces nutrient rich humus<br>No pasteurization of humus required |
|  BIO-LOO | Small volume | Polyphenylen-oxide (plastic)<br>SIZE<br>24-3/16 × 31½ × 25-5/8 | $795 inclusive | 2-4 persons with occasional overloads | Fan 110V-23W<br>Heating foil 110V 30W<br>Pasteurization hot plate 110V-160W | Pasteurization box heats waste and kills pathogenic bacteria<br>Manually operated harrow to mix waste<br>Easy installation<br>Internal heating elements<br>Produces nutrient rich humus |
| BIOLOGICAL TOILET MODEL A  | Small volume | Polyethylene (plastic)<br>SIZE<br>22 × 41 × 31 | $980 inclusive | 2-4 persons with occasional overloads | Fan 110V-23W<br>Drum rotation motor<br>110V-115W<br>3 heating elements 300W(1200 opt.) | Automatic rotating drum mixes waste<br>Easy installation<br>Internal heating elements<br>Produces nutrient rich humus<br>No pasteurization of humus required |

## Wastewater Recycle/Reuse Systems

Description:

Systems which are designed to collect all or a portion of the wastewater from selected activities within the household, to treat these wastewaters and hold them for subsequent reuse within the home. The flowsheets for wastewater reuse and recycle are varied and numerous. One of the major flowsheets involves the recycling of bathing and laundry water for flushing of water carriage toilets (BL/T).

BL/T systems - There is considerable variation in this type of system but it would normally consist of a holding tank, filtration device (paper carriage, sand, diatomaceous earth, etc.) and disinfection process (chlorine or iodine). Make up water (tap water) is brought in as required for toilet flushing demand.

Other systems - Systems involving the treatment of other fractions of the wastewater generated in the home to satisfy a variety of uses have also been developed including one system which purports to have a complete recycle-closed loop process. Many of these systems are still under test.

Applicability:

Wastewater Influent Characteristics:

Depends on system.

Site Conditions:

No requirements

Climatological Conditions:

No requirements

Treatment Capabilities:

Variable treatment is achieved depending upon system developed. These systems will significantly reduce wastewater flow generation (BL/T - will reduce flow about 35%) and may appreciably reduce pollutional loads in resultant wastewater flows.

Operation/Maintenance Requirements:

Labor: Recycle systems involve semi-skilled to skilled labor depending upon system. Maintenance on BL/T systems will include replacement of disinfectant and filter media, cleaning of storage reservoirs and maintenance of mechanical equipment including pumps. Residual disposal.

Power: Most recycle systems will require additional power.

Chemicals: Most recycle systems will require disinfectants and may require coagulants, polymers, filter media and other treatment expendable items.

Residuals: Recycle systmes are designed to remove pollutants from the recycled water. These pollutants normally accumulate in the system as unwanted residues which must be removed and disposed of.

Environmental Concerns:

Health hazards from inappropriate disinfection.

Staining and depositions on toilet or other appliances.

Aesthetics of recycled water.

Health or environmental hazards of residue disposal.

Energy intensive.

Costs:

Installed Costs: Variable
BL/T - $500-$3000
Total Recycle - $10-$15,000

Operation/Maintenance: -
BL/T - $25/$45/yr.

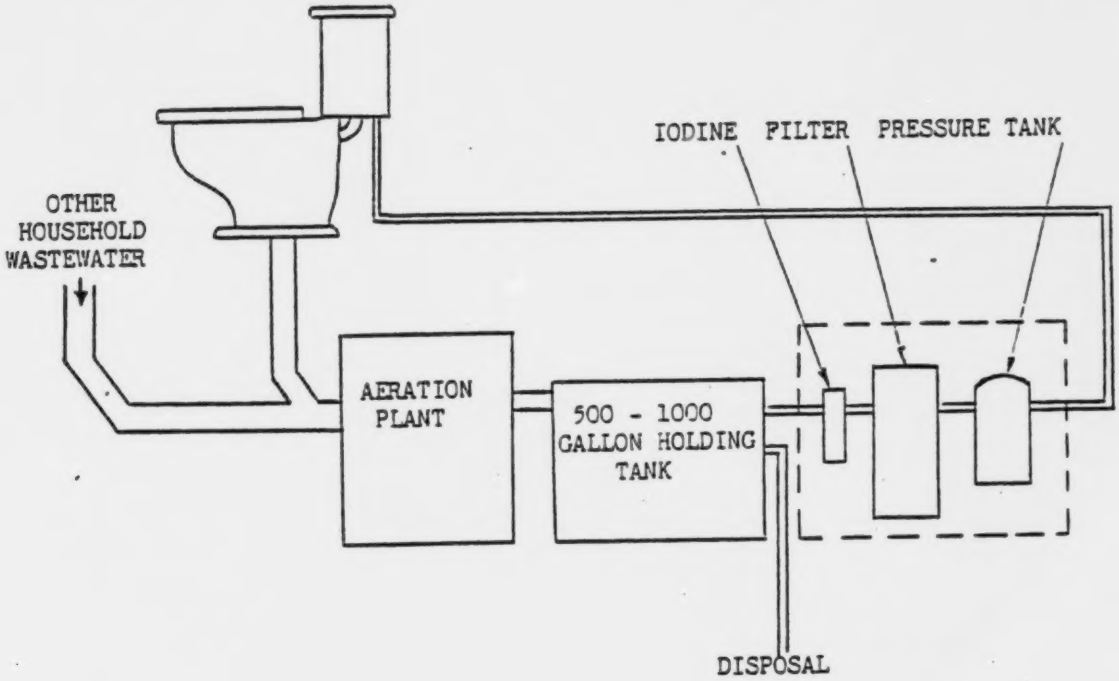
Source Materials:

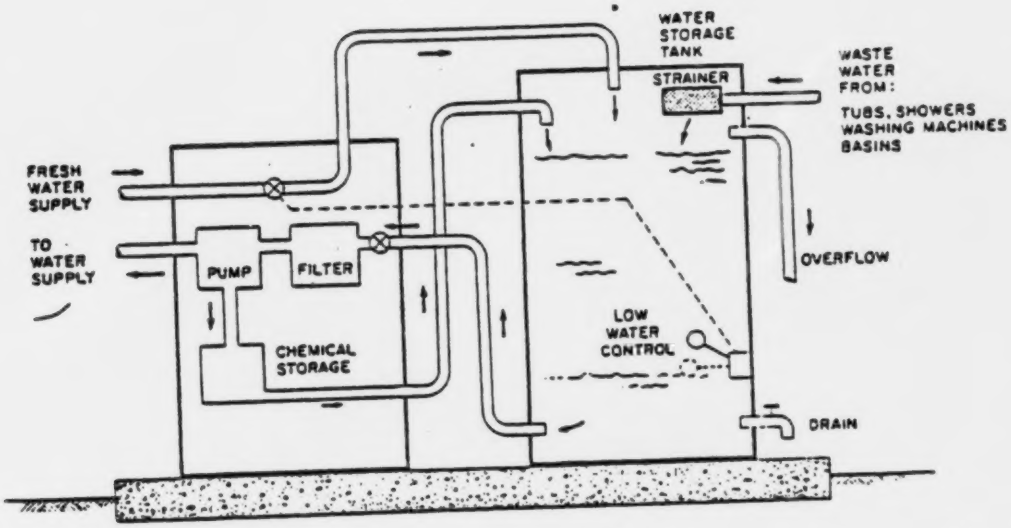
Wallman, H. and S. Cohen, "Demonstration of Waste Flow Reduction From Households," USEPA Report No. 670/2-74-071, Sept. 1974.

Waldorf, L.E., "Boyd County Demonstration Project," - Proceedings of National Conference on Less Costly Wastewater Treatment Systems for Small Communities, USEPA, Reston, VA April, 1977.

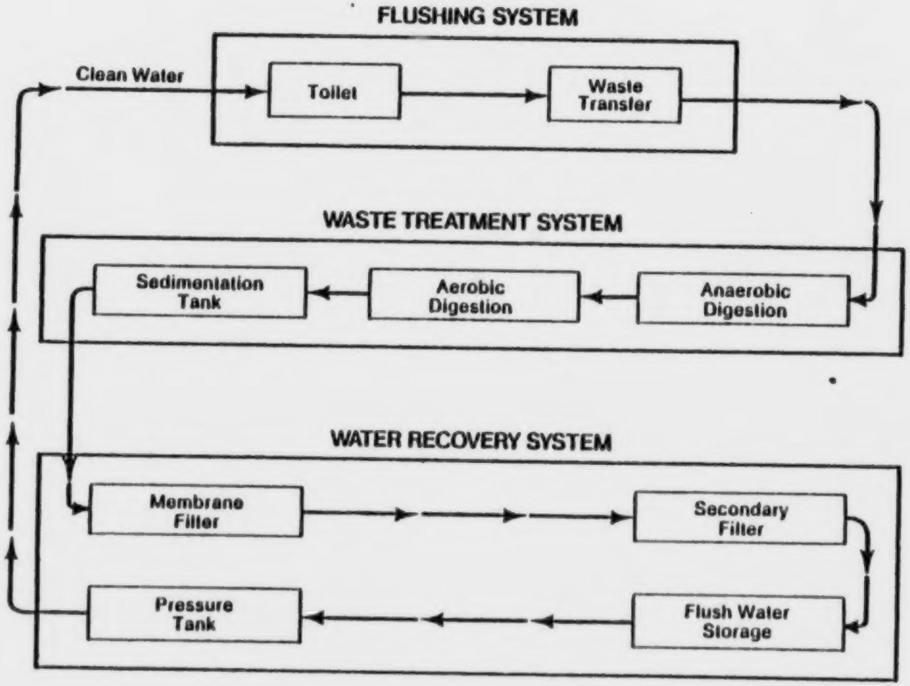
McLaughlin, E.R., "A Recycle System for Conservation of Water In Residences," Proc. Water Conservation and Sewage Flow Reduction With Water Saving Devices, Penn State Univ., Univ. Park, PA, 1975.

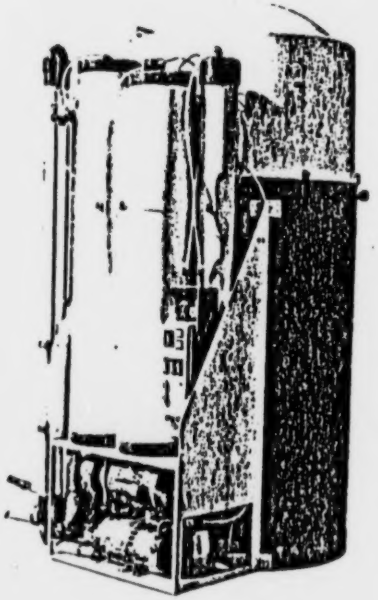
Typical Water Recycle Systems


IODINE
FILTER
PRESSURE TANK
OTHER HOUSEHOLD WASTEWATER
AERATION PLANT
500 - 1000 GALLON HOLDING TANK
DISPOSAL


WATER STORAGE TANK
STRAINER
WASTE WATER FROM:
TUBS, SHOWERS
WASHING MACHINES
BASINS
FRESH WATER SUPPLY
TO WATER SUPPLY
PUMP
FILTER
CHEMICAL STORAGE
OVERFLOW
LOW WATER CONTROL
DRAIN

## Operational Flow Diagram


FLUSHING SYSTEM
Clean Water
Toilet
Waste Transfer
WASTE TREATMENT SYSTEM
Sedimentation Tank
Aerobic Digestion
Anaerobic Digestion
WATER RECOVERY SYSTEM
Membrane Filter
Secondary Filter
Pressure Tank
Flush Water Storage



## Waste Segregation - Flowsheets

Description:

The objectives of in-house waste segregation practice are (1) to reduce the volume of wastewater to be treated, (2) to reduce the mass of a specific pollutant to be treated, or (3) to avoid the dilution of a particular pollutant to be treated. These objectives may be accomplished through a number of procedures within the home; the most practical of these procedures are presented in Table 1.

Management of black and grey waters in the segregation of these wastes is briefly depicted in Table 2.

## Table 1

## Waste Segregation Practices

| Strategy | Impacts on Wastewater | | Comments |
|---|---|---|---|
| | Reduce Volume | Reduce Pollutant Mass | |
| Use of Non Phosphate Detergent | None | P | May Reduce P Up to 50% |
| Eliminate Garbage Disposal | Slight | BOD, S, FOG, N, P | May Reduce:<br>BOD-25%<br>S-35%<br>N-5%<br>P-2%<br>Flow-4% |
| Recycle B,L to Toilet | Significant | BOD, P, Pathogen | May Reduce Flow to 35% |
| Segregate Toilet From B,L,T | Significant | BOD, P, N, Pathogens, S | See Table 1-11*<br>Requires Separate Treatment of Black and Grey Waters |

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* EPA Technology Transfer Seminar Publication - "Alternatives for Small Wastewater Treatment Systems - On Site Disposal," Otis, et al., p. 38.

## Table 2

## Management of Black and Grey Waters

- Black Waters (Toilet + Garbage)
  - Very Low Volume Flush - Holding Tank
    - Disinfection - Land Disposal
    - Treatment Plant
    - Evapotranspiration
  - Closed Loop Toilet - Holding Tank
    - Disinfection - Land Disposal
    - Treatment Plant
  - Composting Toilet - Soil Amendment
  - Incinerator Toilet - Soil Amendment/Refuse

- Grey Waters (Laundry/Bath/Kitchen
  - Separation Process (Septic Tank)
    - Soil Absorption Field
    - Disinfection - Irrigation
    - Filtration (Disinfection)-(Nutrient Removal) - Surface Water
    - Evapotranspiration

## Septic Tank

Description:

An enclosed, baffled sedimentation tank through which raw sewage flows continuously at a rate slow enough to permit settleable and floatable solids to be removed from the waste stream. The sludge and scum is allowed to accumulate and undergo anaerobic digestion to reduce its volume and volatile content. Periodically the solids must be removed.

Applicability:

Wastewater Influent Characteristics:

Volume: Restricted only by structural strength

Pretreatment: None

Site Conditions:

Soils/Geology: None
Topography: None
Setback Distances: Check local codes

Climatological Conditions: None

Treatment Capability:

A turbid, malodorous effluent is produced.

$BOD_5$: ~ 150 mg/L
SS: ~ 60 mg/L
Nitrogen: ~ 55 mg/L - total nitrogen (70% ammonium, 30% organic)
Phosphorus: ~ 15 mg/L (80% inorganic)
Pathogenic Bacteria: $>10^5$/100 ml fecal coliforms
Virus: Insufficient data

Operation/Maintenance Requirements:

Labor: Inspection and pumping when necessary
Power: None
Chemicals: None
Residuals: Septage, a high strength, odorous sludge removed every 1 to 8 years.

Environmental Concerns:

Odors

Septage disposal

Costs:

| | Individual Home | Multiple Home |
|---|---|---|
| Installed Costs: | \$300-\$350 | Cast in place |
| Maintenance: | \$40-\$60/pumping every 1 to 3 yrs | 2-3¢/gallon of septage pumped |

Comments:

Septic tank designs are usually regulated by local codes.

Tanks serving several residences should have at least two compartments but no more than four. The first compartment should be at least 1/2 of the total volume.

Shallow tanks are preferred over deep tanks of equal volume.

Sanitary tees or other small volume baffles are recommended rather than single slabs extending across the width of the tank.

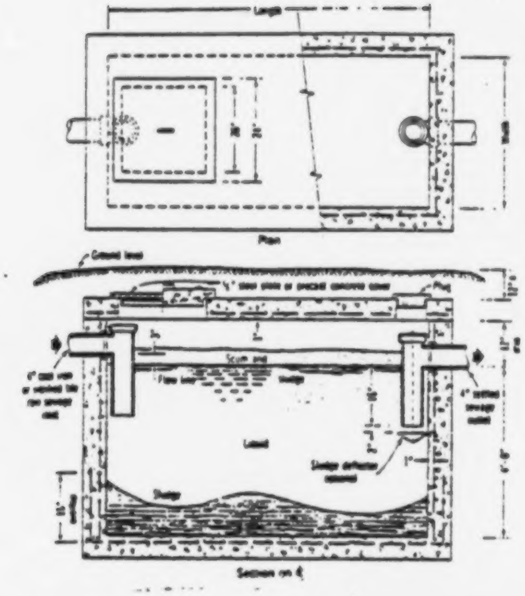
Tanks should be located near a road or driveway to facilitate pumping.

Source Materials:

Management of Small Waste Flows, pp. A-150 to A-192.

Manual of Septic Tank Practice, 1967. U.S. Public Health Service Publication No. 526, Washington, D.C.

Baumann, E.R., et al., 1978. "Septic Tanks," Home Sewage Treatment Amer. Soc. Agr. Engr. Pub. 5-77, St. Joseph, Michigan.


Length
Width
Plan
Ground level
Plug
Scum
Liquid
Sludge
Section on ℄

Schematic Details of A Septic Tank

## Extended Aeration Processes

Description:

A biological wastewater treatment process employing high concentrations of microorganisms under aerobic conditions. The process consists of an aeration step followed by clarification whereby the biomass is separated from the treated wastewater. A provision is made for recycle of a portion of the separate biomass back to the aeration step.

Applicability:

Wastewater Influent Characteristics:

Volume: Limited only by site conditions

Pretreatment: Ideally should be preceded by trash trap or sedimentation facility, typically a septic tank for individual homes.

Site Conditions:

Soils/Geology: No requirements
Depth to Groundwater: No requirements
Depth to Bedrock: No requirements
Topography: No requirements
Setback Distances: Check local codes

Climatological Conditions: None

Treatment Capability:

BOD5: 75-90% reduction depending on process
SS: 75-90%
Nitrogen: Normally nitrified
Phosphorus: Little reduction, highly variable depending on waste character.
Indicator Organisms/Pathogen: Normally 90-99% reductions

Operation/Maintenance Requirements:

Labor: Labor intensive; requires semi-skilled personnel.
Power: Required, variable depending upon aeration equipment and pumps.
Chemicals: Usually not required.
Residuals: Sludge must be wasted and disposed of every 8-10 months for household units.

Environmental Concerns:

Surface water quality impairment depending upon specified use.

Improper residuals disposal to land may cause groundwater or surface water contamination.

Poorly maintained plant may produce odors.

Energy intensive

Noise

Costs:

| | Household Unit ( 1000 gal.) |
|---|---|
| Installed Cost: | $1500-2500 |
| Operation/Maintenance: | |
| Labor: (12-24 hr./yr.) | $60-120/yr. |
| Power: (5-10 Kwhr/d) | $75-108/yr. |

Source Materials:

Otis, R.J. and W.C. Boyle, 1976. "Performance of Single Household Treatment Units," J. Env. Engr. Div., A.S.C.E., 102, EE1, 175-189.

A.T. Voell and R.A. Vance, 1974. "Home Aerobic Wastewater Treatment Systems - Experience in a Rural County," Ohio Home Sewage Disposal Conference, Ohio State University, Columbus, Ohio.

M.B. Glasser, 1974. "Garrett County Home Aeration Wastewater Treatment Project," Bureau of Sanitary Engineering, Maryland State Department of Health and Mental Hygiene, Baltimore, Maryland.

N.J. Hutzler, and L.E. Waldorf, J. Fancy, 1977. "Performance of Aerobic Treatment Units," Proc. of Second National Home Sewage Treatment Symposium, Am. Soc. Ag. Engr., Chicago, Illinois.

E.R. Bennett and K.D. Linstedt, 1975. "Individual Home Wastewater Characterization and Treatment," Completion Report No. 66, Env. Res. Center, Colorado State University, Fort Collins, Colorado.

Tipton, D.W., 1975. "Experience of a County Health Department With Individual Aerobic Sewage Treatment Systems," Jefferson County Health Department, Lakewood, Colorado.

National Sanitation Foundation, Ann Arbor, Michigan.

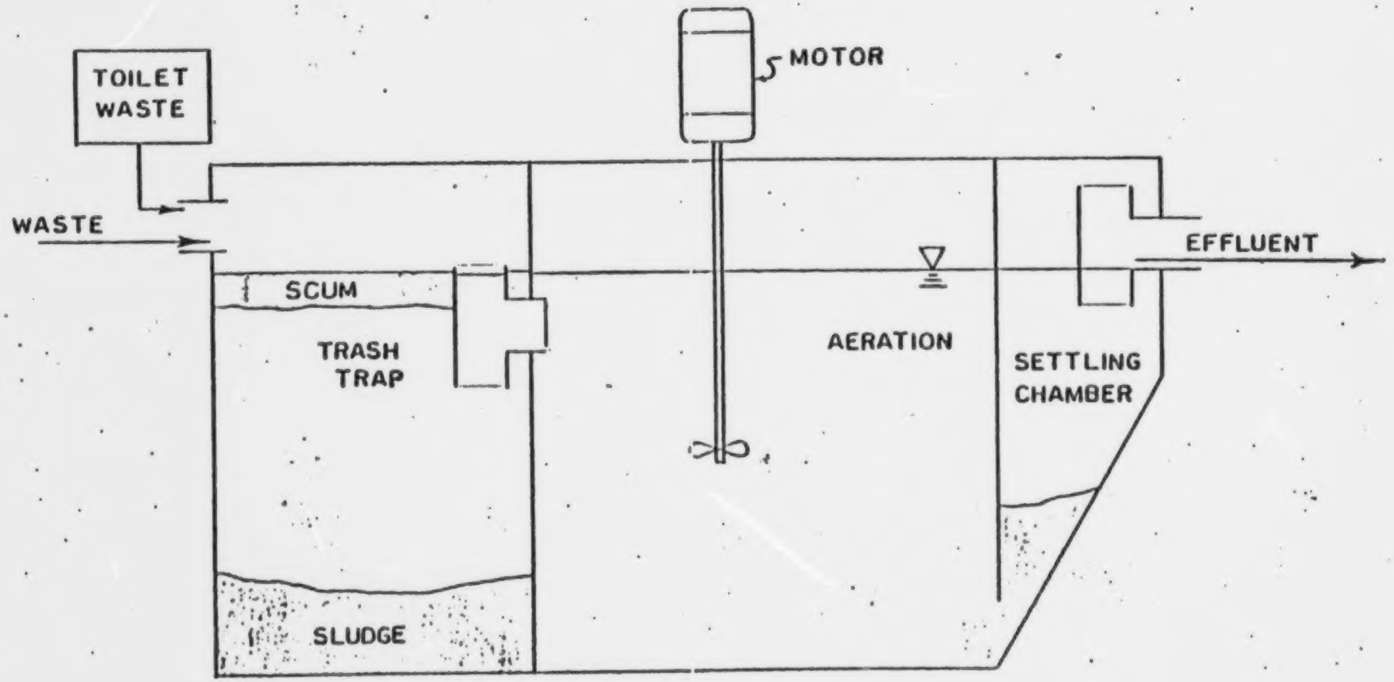
Demonstrations:

Boyd County Demonstration Project, Appalachian Regional Commission, Washington, D.C.

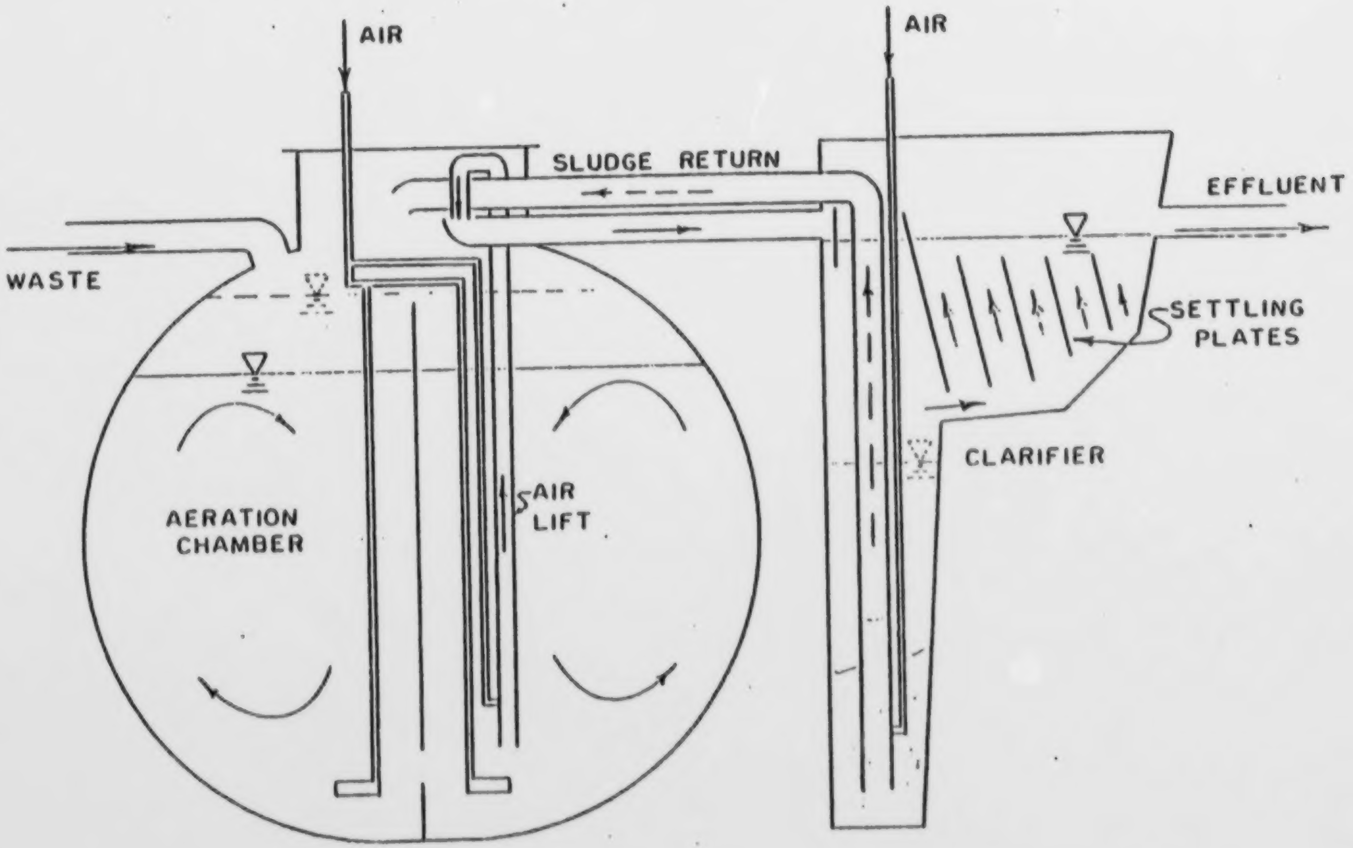
Installation of 38 Aerobic Units Representing Several Manufacturers Under Supervision and Monitoring of a Licensed Treatment Plant.

Source: L.E. Waldorf, Senior Program Coordinator, Appalachian Regional Commission, Washington, D.C.

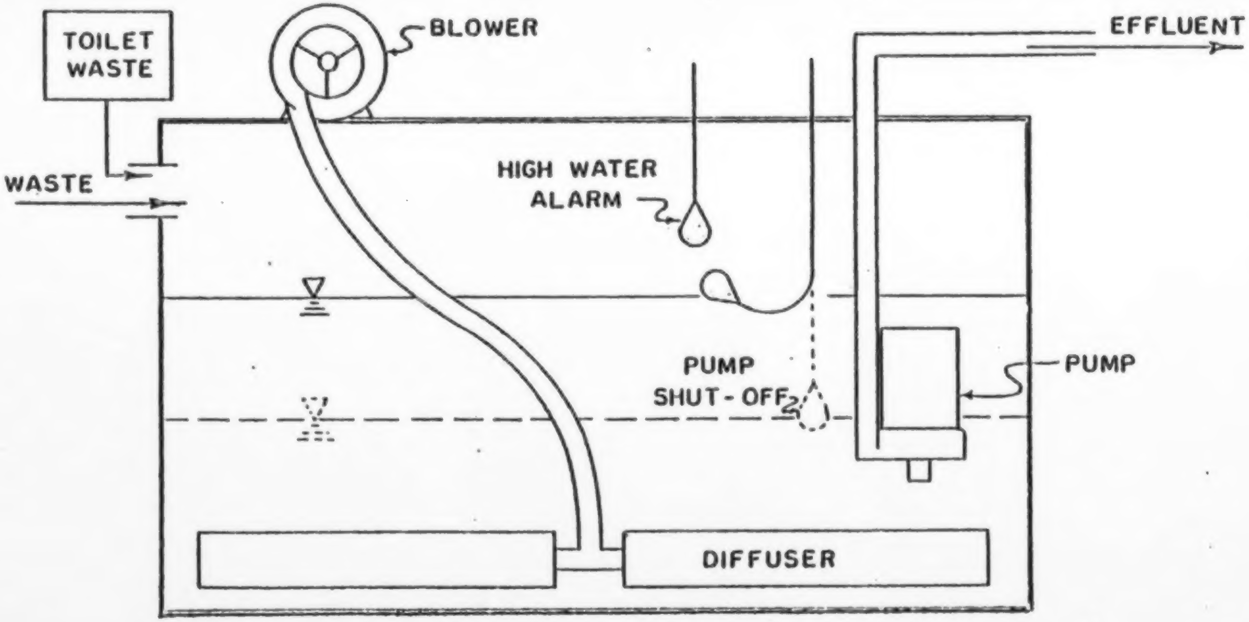
# EXTENDED AERATION


TOILET WASTE
WASTE
MOTOR
SCUM
TRASH TRAP
SLUDGE
AERATION
SETTLING CHAMBER
EFFLUENT

## EXTENDED AERATION


AIR
AIR
SLUDGE RETURN
EFFLUENT
WASTE
SETTLING PLATES
CLARIFIER
AIR LIFT
AERATION CHAMBER

## BATCH AERATION


TOILET WASTE
BLOWER
EFFLUENT
WASTE
HIGH WATER ALARM
PUMP
PUMP SHUT-OFF
DIFFUSER

## Fixed Film Treatment Processes

Description:

A biological wastewater treatment process employing a large surface area (fixed media) upon which microorganisms will grow and over which wastewater is distributed so that the biomass may contact and metalboize the pollutants within the waste streams. These processes may be aerobic or anaerobic and are normally followed by a solid-liquid separation step. Recycle of the treated wastewater back to the fixed media may also be practiced. Aeration may be provided by natural ventilation, by mechanical aeration or by forced air ventilation depending upon the device employed.

Three basic devices are considered in this section: the packed tower, the rotating contactor and the submerged media system.

Packed tower: A fixed film system employing rock, redwood slats or a variety of synthetic packing media which is placed within a tank volume equipped with underdrains and a distribution system. Waste trickles over the media surface and is collected through underdrains. Oxygen is provided by natural ventilation or forced air blowers.

Rotating contactor: A fixed film system employing a series of circular plastic discs mounted on a horizontal shaft within a tank. The partially submerged discs are rotated at relatively low speed through wastewater which flows through the tank. Aeration is normally provided by gas transfer to the biomass as the discs rotate in the air. Effluent is normally settled or filtered prior to further treatment or disposal.

Submerged media system: A fixed film system employing a variety of packing materials which are submerged within the wastewater to be treated. Normally, the waste passes through (or up through) the media. If aerobic, oxygen may be provided by diffused aeration or mechanical surface entrainment.

Applicability:

Wastewater Influent Characteristics:

Volume: Limited only by site conditions.

Pretreatment: Must be preceded by solid-liquid separation process, typically a septic tank for individual homes.

Site Conditions:

Soils/Geology: None
Depth to Groundwater: None
Depth to Bedrock: None
Topography: None
Setback Distances: See local codes

Climatological Conditions:

Fixed film systems are temperature sensitive and should normally be covered to prevent icing and to prevent heat loss. Rotating contactors are best covered to avoid excessive algal growths on discs.

Treatment Capability:

$BOD_5$: 75-95% reduction depending on process.
SS: 75-95% reduction depending on process.
Nitrogen: Normally nitrified if aerobic process
Phosphorus: Little reduction
Indicator Organisms: Normally 90-99% reductions

Operation/Maintenance Requirements:

Labor: Fixed film systems are normally not labor intensive and require little maintenance since there are few moving parts; attention should be given to surface clogging or ponding or heavy biomass accumulation; maintenance of ventilation or aeration is critical to all aerobic systems.
Power: Required, but variable depending upon aeration device, pumps or drive mechanisms (2.0 to 4.0 kwh/d).
Chemicals: Usually not required.
Residuals: Sludge must be handled and disposed of from these processes. Normally sludge is wasted to septic tank and is pumped with septage. May increase septage pumping frequency to 1.5 to 2 year cycles.

Environmental Concerns:

Surface water quality impairment depending upon use

Poorly maintained plant may produce odors

Residuals disposal

Energy required

Costs:

Installed Cost: $1500-2500

Operation and Maintenance:

Labor: (8-12 hr/yr) $40-60/yr

Power: (2-4 kwhr/d) $30-60/yr

Source Materials:

Otis, R.J. and W.C. Boyle, 1976. "Performance of Single Household Treatment Units," J. Env. Engr. Div., A.S.C.E., 102, EE1, 175-189.

A.T. Voell and R.A. Vance, 1974. "Home Aerobic Wastewater Treatment Systems - Experience in a Rural County," Ohio Home Sewage Disposal Conference, Ohio State University, Columbus, Ohio.

M.B. Glasser, 1974. "Garrett County Home Aeration Wastewater Treatment Project," Bureau of Sanitary Engineering, Maryland State Department of Health and Mental Hygiene, Baltimore, Maryland.

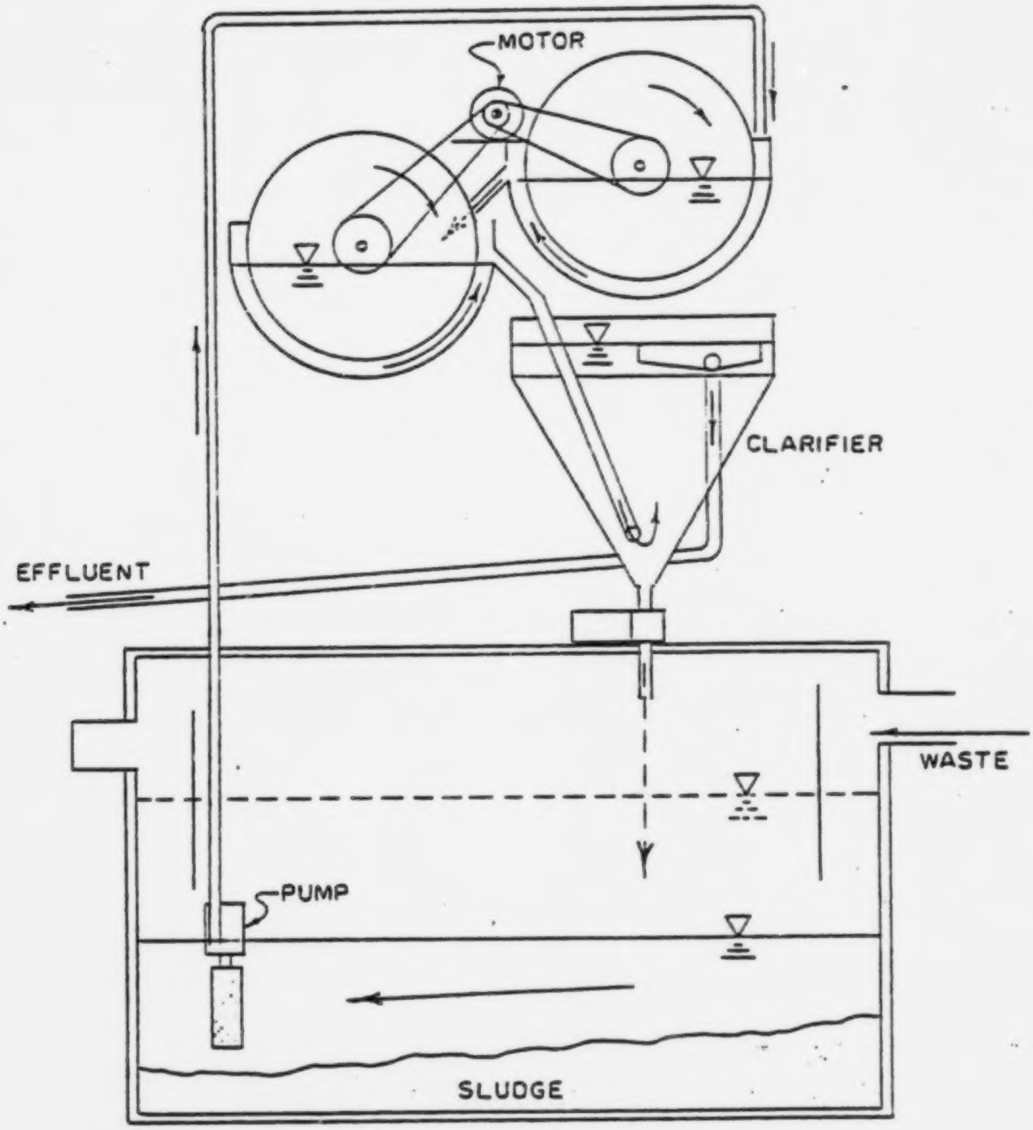
N.J. Hutzler and L.E. Waldorf, J. Fancy, 1977. "Performance of Aerobic Treatment Units," Proc. of Second National Home Sewage Treatment Symposium, Am. Soc. Ag. Engr., Chicago, Illinois.

E.R. Bennett and K.D. Linstedt, 1975. "Individual Home Wastewater Characterization and Treatment," Completion Report No. 66, Env. Res. Center, Colorado State University, Fort Collins, Colorado.

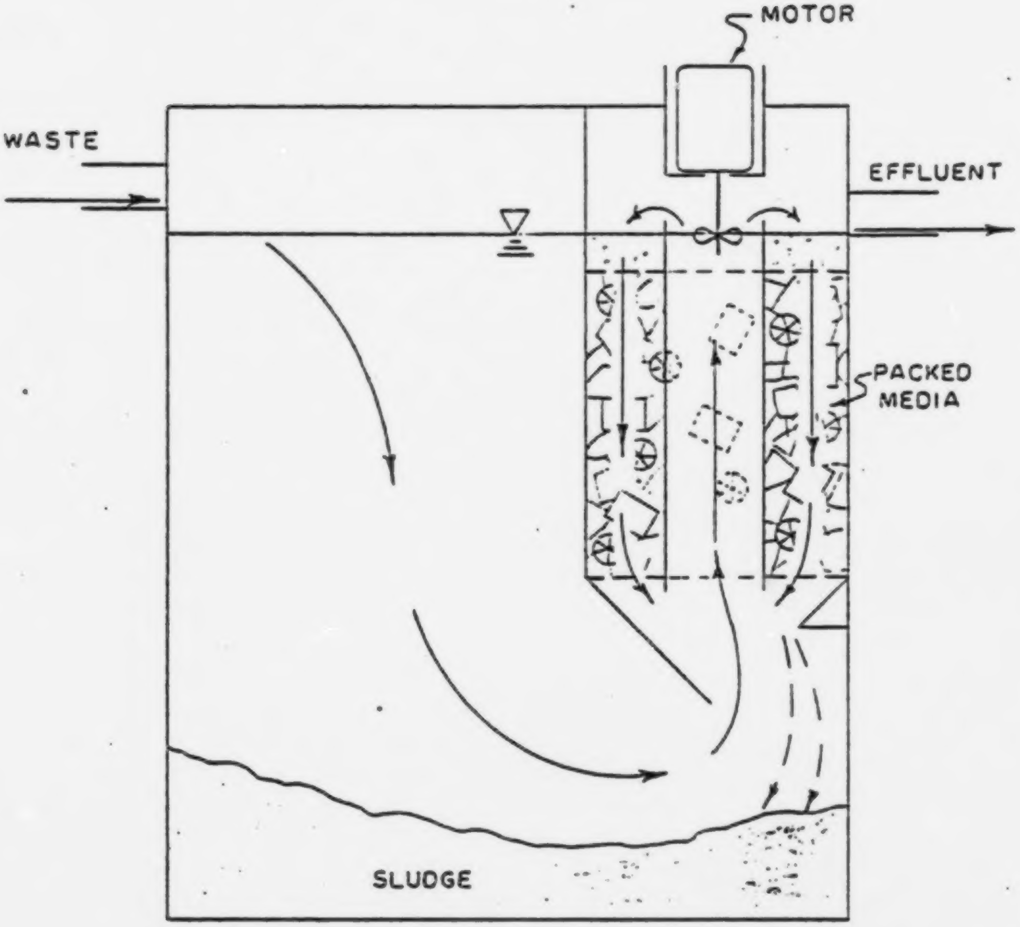
Tipton, D.W., 1975. "Experience of a County Health Department With Individual Aerobic Sewage Treatment Systems," Jefferson County Health Department, Lakewood, Colorado.

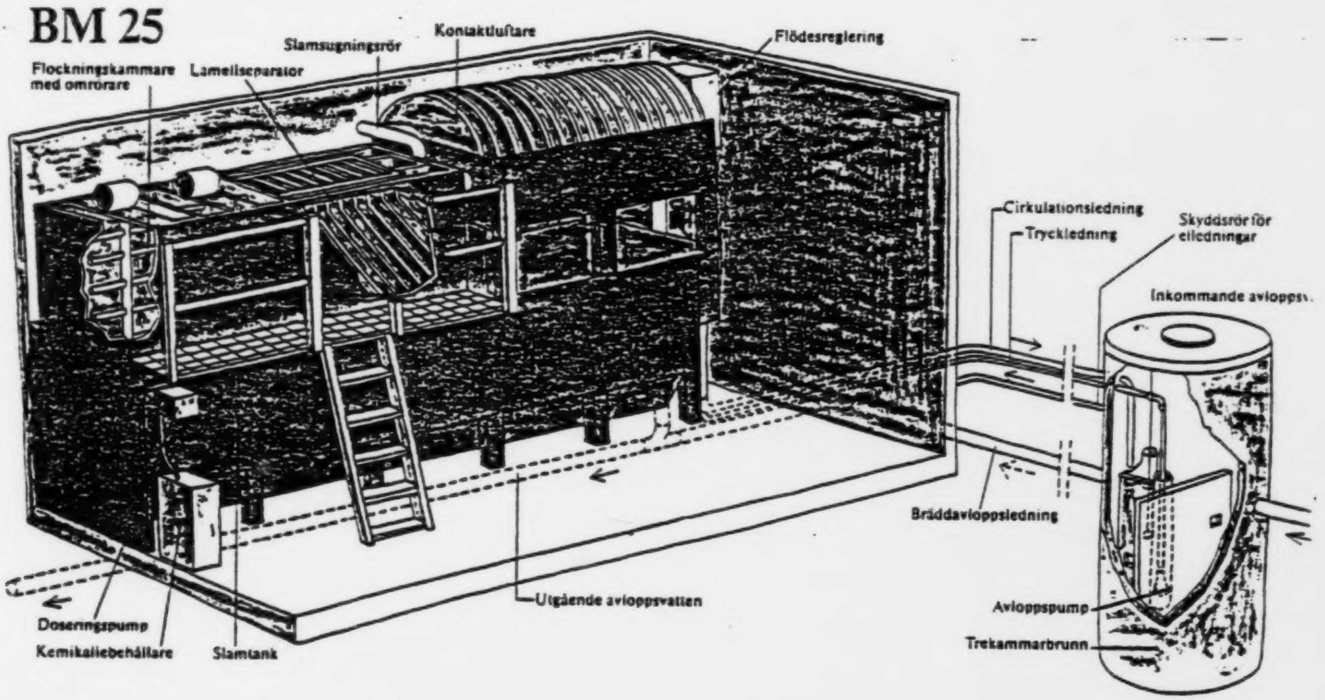
National Sanitation Foundation, Ann Arbor, Michigan.

# ROTATING DISKS


MOTOR
CLARIFIER
EFFLUENT
WASTE
PUMP
SLUDGE

SUBMERGED
MEDIA


MOTOR
WASTE
EFFLUENT
PACKED MEDIA
SLUDGE


BM 25
Flockningskammare med omrörare
Lamellseparator
Slamsugningsrör
Kontaktluftare
Flödesreglering
Cirkulationsledning
Tryckledning
Skyddsrör för elledningar
Inkommande avloppsv.
Bräddavloppsledning
Utgående avloppsvatten
Avloppspump
Trekammarbrunn
Doseringspump
Kemikaliebehållare
Slamtank

Package Biological/Chemical Process

# Intermittent Sand Filters

## Description:

A biological and physical wastewater treatment unit consisting of an underdrained bed of granular material, usually sand (e.s.: 0.2-0.6 mm, u.c.: <4). The filter surface is flooded intermittently with pretreated wastewater at intervals which permit the surface to drain between applications. The filtrate is collected by the underdrains for further treatment or discharge. Access to the filter surface is provided for periodic maintenance. Loading rates range from 5 to 15 gpd/ft$^2$ depending on influent characteristics.

## Applicability:

Wastewater Influent Characteristics:

Volume: Size limited by land availability and labor requirements for maintenance. A flow of 250,000 gpd is considered the maximum to be handled by this treatment.

Pretreatment: Sedimentation, provided by settling tanks, septic tanks or Imhoff tanks. Higher rates of application are permitted with secondary effluent.

Site Conditions:

Soils/Geology: None
Topography: None
Setback Distances: If a septic primary effluent is applied to uncovered filters, the filters should be reasonably isolated from dwellings.

Climatological Conditions:

Covered filters are required in areas with extended periods of sub-freezing weather.

## Treatment Capability:

A sparkling, clear effluent is produced but the quality of the final effluent depends on the type of wastewater applied, application rate, sand size, air temperature and manner of operation.

$BOD_5$: Usually less than 10 mg/L, frequently below 5 mg/L.
SS: Usually less than 10 mg/L, frequently below 5 mg/L.
Nitrogen: Nearly complete nitrification except during winter when cold temperatures can retard nitrification.
Phosphorus: Negligible removal
Pathogenic bacteria: Large reductions though substantial numbers remain which may require that the filtrate be disinfected prior to discharge to surface waters.
Virus: Insufficient data.

Operation/Maintenance Requirements:

Labor:

Primary effluent: Raking of sand surface and resting filter for 30-60 days after clogging. Periodic replacement of top 2-4 inches of sand. Surface area must be kept free of weeds.

Secondary effluent: Replacement of top 2-3 inches of sand after clogging. Runs can be extended between sand replacements by raking the surface when it first becomes clogged. Surface area must be kept free of weeds.

Power: Pumps may be necessary to dose the filters. Siphons are recommended were head is available.
Chemicals: None
Residuals: Sand with putrescible organic matter removed from the filter surface.

Environmental Concerns:

Low energy requirements

Ammonia removal is provided

Dissolved oxygen residual in effluent

Nutrient addition to surface waters

Odors from open filters receiving septic wastewater

Costs:

Installed Costs: $10-$15/sq.ft.

Maintenance: $1/sq.ft./yr.

Comments:

Headloss through the filter is 4 to 5 feet. If siphons are used, allow another 4 to 6 feet. Therefore, with siphons the total head requirements from sewer inlet to final effluent outlet is approximately 10 feet.

Provide a number of small filters rather than a few large filters. If primary effluent is used, standby units must be provided to allow a 30-60 day resting period of each filter after clogging.

Source Materials:

Management of Small Waste Flows, pp. A-193 to A-216.

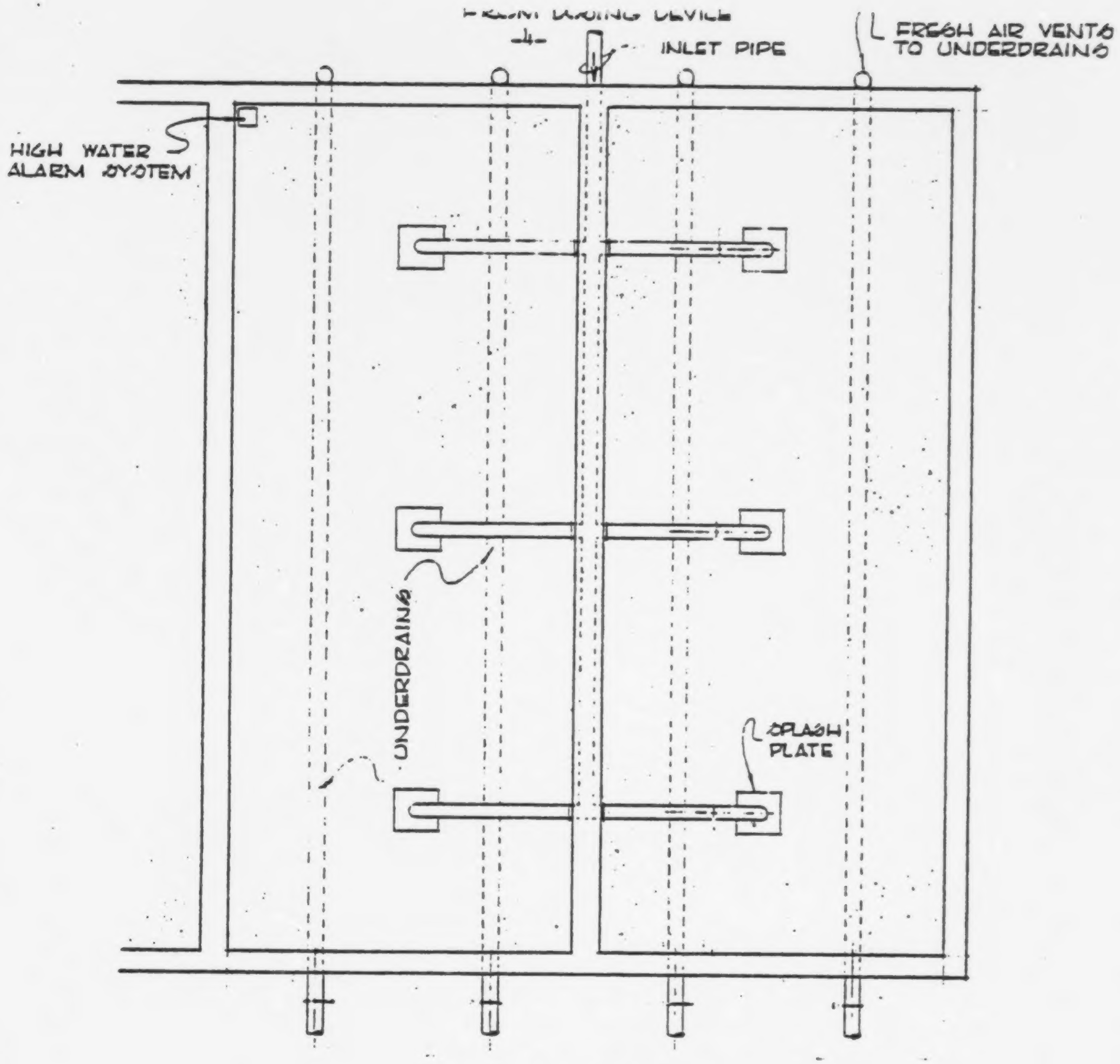
Water Pollution Control Federation, 1967. Sewage Treatment Plant Design, Manual of Practice No. 8, Washington, D.C.

Sauer, D.K. and W.C. Boyle, 1978. "Intermittent Sand Filtration and Disinfection of Small Wastewater Flows," Home Sewage Treatment, Amer. Soc. Agr. Engr. Publication 5-77, St. Joseph, Michigan.

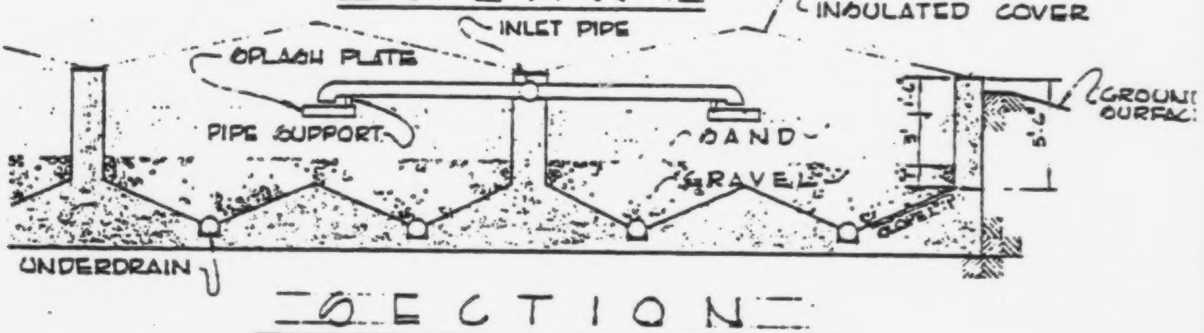
Marshall, G.R. and E.J. Middlebrooks, 1974. "Intermittent Sand Filtration to Upgrade Existing Wastewater Treatment Facilities," PRJEW 115-2, Utah Water Research Laboratory, Utah State University, Logan, Utah.

Clark, H.W. and S. Gage, 1909. "A Review of Twenty-One Years Experiments Upon the Purification of Sewage at the Lawrence Experiment Station," Fortieth Annual Report of the State Board of Health of Massachusetts, Public Document No. 34, Boston, Massachusetts.

Iskandar, I.K., et al., 1976. "Wastewater Renovation by a Prototype Slow Infiltration Land Treatment System," CRREL Report 76-19, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.


FROM DOSING DEVICE
-4-
INLET PIPE
FRESH AIR VENTS TO UNDERDRAINS
HIGH WATER ALARM SYSTEM
UNDERDRAINS
SPLASH PLATE

PLAN


INSULATED COVER
INLET PIPE
SPLASH PLATE
PIPE SUPPORT
SAND
GRAVEL
GROUND SURFACE
1'-6"
3'
5'-0"
SLOPE
UNDERDRAIN

SECTION

DETAIL- SAND FILTER (SINGLE UNIT)

## Subsurface (or Buried) Sand Filter

Description:

A biological and physical wastewater treatment unit consisting of a buried underdrained bed of sand (e.s.: 0.4-0.6 mm; u.c.: <4.0). Pretreated wastewater is applied to the filter surface intermittently via perforated pipe once or twice daily. The filtrate is collected by the underdrains for further treatment or discharge. Loading rates used are 1 gpd/$ft^2$ or less.

Applicability:

Wastewater Influent Characteristics:

Volume: Size limited by land availability

Pretreatment: Sedimentation, typically provided by septic tanks

Site Conditions:

Soils/Geolcgy: Unless lined, at least two feet of undisturbed soil should exist between the bottom of the filter excavation and the highest seasonal ground water elevation or bedrock.
Topography: None
Setback Distances: Check local codes

Climatological Conditions: None

Treatment Capability:

A sparkling, clear effluent is produced.

$BOD_5$: Less than 30 mg/L frequently below 10 mg/L
SS: Less than 40 mg/L
Nitrogen: Nearly complete nitrification
Phosphorus: Negligible removal
Pathogenic Bacteria: Large reductions though significant numbers can remain
Virus: Insufficient data

Operation/Maintenance Requirements:

Labor: None
Power: Pumps may be necessary to dose the filters. Siphons are recommended where sufficient head is available
Chemicals: None
Residuals: None

Environmental Concerns:

Ammonia removal provided

Dissolved oxygen residual in effluent

Nutrient addition to surface waters

Costs:

Installed Costs: $5-$15/sq.ft.

Maintenace: -

Comments:

Filters need to be lined if groundwater contamination is not a concern.

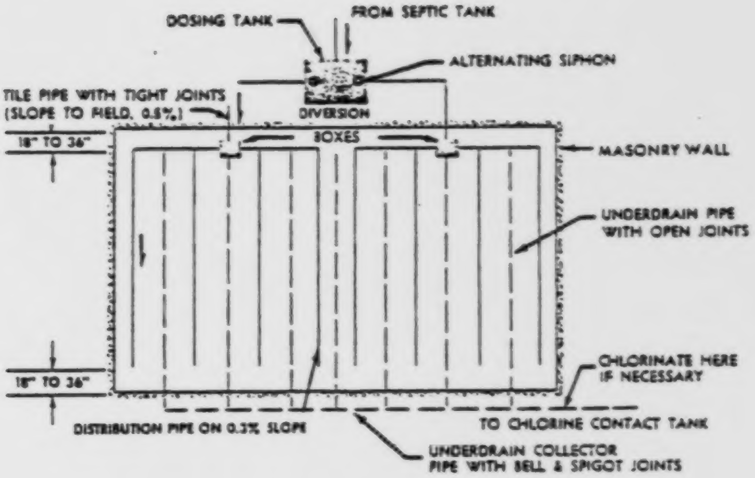
Provide at least two filters with alternate dosing by automatic siphons. A third filter of equal size is recommended for standby in larger installations.

Source Materials:

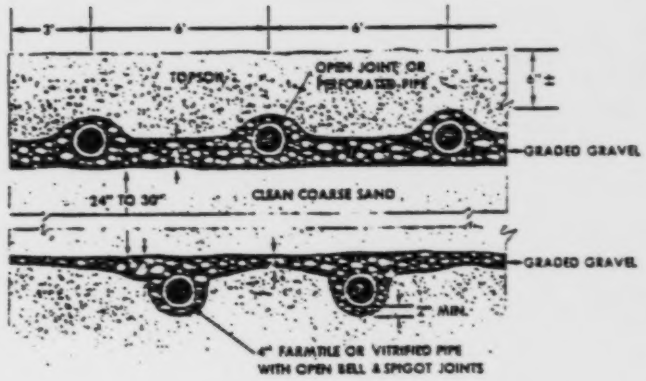
*Manual of Septic Tank Practice*, 1967. U.S. Public Health Service Publication No. 526, Washington, D.C.

Hills, D.J. and R.B. Krone, 1971. "Hydraulically Ventilated Underground Filter," Proc. Paper 8596, *Journal of the Sanitary Engineering Division*, ASCE. 97, SA6, pp. 851-866.

Salvato, J.A., Jr., 1955. "Experience With Subsurface Sand Filters," *Sewage and Industrial Wastes Journal*, 27, 8, p. 909.


DOSING TANK
FROM SEPTIC TANK
ALTERNATING SIPHON
TILE PIPE WITH TIGHT JOINTS (SLOPE TO FIELD, 0.5%)
DIVERSION BOXES
18" TO 36"
MASONRY WALL
UNDERDRAIN PIPE WITH OPEN JOINTS
CHLORINATE HERE IF NECESSARY
18" TO 36"
DISTRIBUTION PIPE ON 0.3% SLOPE
TO CHLORINE CONTACT TANK
UNDERDRAIN COLLECTOR PIPE WITH BELL & SPIGOT JOINTS

PLAN


3'
6'
6'
TOPSOIL
OPEN JOINT OR PERFORATED PIPE
6"±
GRADED GRAVEL
24" TO 30"
CLEAN COARSE SAND
GRADED GRAVEL
2" MIN.
4" FARMTILE OR VITRIFIED PIPE WITH OPEN BELL & SPIGOT JOINTS

SECTIONAL ELEVATION

Typical Plan and Section of a
Subsurface Sand Filter

## Recirculating Sand Filters

Description:

A biological and physical wastewater treatment unit consisting of a filter of coarse sand (e.s.: 0.6-1.5 mm, u.c.: <2.5) and a recirculation tank. The recirculation tank collects and stores settled wastewater and sand filter effluent until the mixture is pumped onto the filter at the desired recycle rate. The filtrate is returned to the recirculation tank. If the tank is full, the filtrate is discharged. Loading rates are less than 3 gpd/ft$^2$ based on forward flow. Access to the filter surface is provided for periodic maintenance.

Applicability:

Wastewater Influent Characteristics:

Volume: Originally developed for single household applications. Larger systems have not been built though size should only be limited by land and labor requirements.

Pretreatment: Sedimentation, provided by settling tanks, septic tanks or Imhoff tanks.

Site Conditions:

Soils/Geology: None
Topography: None
Setback Distances: Check local codes

Climatological Conditions:

Covered filters are required in areas with extended periods of subfreezing weather.

Treatment Capability:

BOD$_5$: Usually less than 5 mg/L
SS: Usually less than 5 mg/L
Nitrogen: Complete nitrification
Phosphorus: Negligible removal
Pathogenic bacteria: Insufficient data
Virus: Insufficient data

Operation/Maintenance Requirements:

Labor: Removal and replacement of sand when filter clogs. Periodic servicing of pump.
Power: Power for pump recirculating at a rate of 4 times forward flow.
Chemicals: None
Residuals: Sand with putrescible organic matter removed from filter surface.

Environmental Concerns:

Low energy requirement

Ammonia removal is provided

Dissolved oxygen residual in effluent

Nutrient addition to surface waters

Sand disposal

Costs:

None available

Comments:

Headloss through the filter is 4 to 5 feet. To avoid the use of two pumps or deep excavations, the filter has been constructed above ground or upslope on a steep embankment to permit gravity flow back to the recirculation tank.

Source Materials:

Hines, M. and R.E. Favreau, 1975. "Recirculation Sand Filter: An Alternative to Traditional Sewage Absorption Systems," Home Sewage Disposal, Amer. Soc. Agr. Engr. Publication Proc-175. St. Joseph, Michigan.

Bowne, W.C., 1977. "Experience in Oregon With the Hines-Favreau Recirculating Sand Filter," presented at Northwest States Conference on On-Site Sewage Disposal.

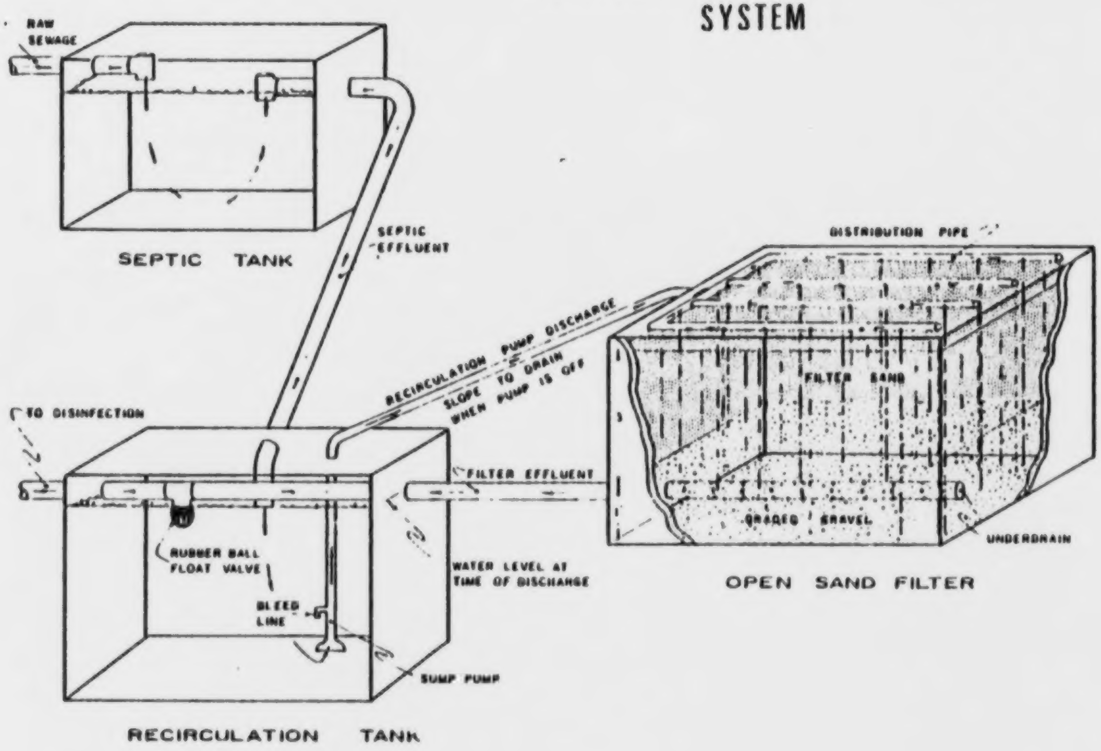
Demonstration Installations:

Oregon State Department of Environmental Quality

System: Individual home installations

Contact: Mark R. Ronayne, Sanitarian

# RECIRCULATING SAND FILTER SYSTEM


RAW SEWAGE
SEPTIC TANK
SEPTIC EFFLUENT
DISTRIBUTION PIPE
RECIRCULATION PUMP DISCHARGE
SLOPE TO DRAIN WHEN PUMP IS OFF
FILTER SAND
TO DISINFECTION
FILTER EFFLUENT
GRADED GRAVEL
UNDERDRAIN
RUBBER BALL FLOAT VALVE
WATER LEVEL AT TIME OF DISCHARGE
BLEED LINE
SUMP PUMP
RECIRCULATION TANK
OPEN SAND FILTER

## Disinfection - The Halogens: Chlorine and Iodine

Description:

Chemical disinfectants which are extremely effective against bacterial and viral pathogens found in wastewaters, both chlorine and iodine are powerful oxidizing agents and are capable of oxidizing organic matter including organisms at very rapid rates and in relatively small concentrations.

Chlorine - This halogen can be added to wastewaters as the gas ($Cl_2$) a liquid (NaOCl or Ca $(OCl)_2$) or a solid (Ca $(OCl)_2$). Because the gas can represent a safety hazard and is highly corrosive, chlorine would normally be added in small flows applications as a solid or liquid. The most common type of feeder for small waste flows has been the stacked-solid tablet feeder employing Ca $(OCl)_2$. Dosage is controlled by flow control weirs or by diversion of a portion of the waste through the unit. Dose requirements are dependent upon waste characteristic but may range from 30-45 mg/L for septic tank effluent to 1-5 mg/L for sand filtered effluents. Contact times normally range from 3 to 24 hours in small flows systems due to reasonable minimum contact tank sizes.

Iodine - The halogen, iodine, is normally used in a crystaline form ($I_2$) for waste and water treatment applications. It is usually added to the water to be treated as a solution pumped from an iodine saturator. Since iodine is only sparingly soluble in water, 300 mg/L at 20° C, iodine crystals are normally contacted with tap water in the saturator. Iodine solution is subsequently fed to the waste stream. Dosage of iodine in wastewater is also dependent upon waste character and normally ranges from 5-10 mg/L for sand filtered effluent. Contact times would be similar to that of chlorine.

Applicability:

Wastewater Influent Characteristics:

Volume: No limitations

Pretreatment: Both chlorine and iodine are consumed in non-specific side reactions by reduced compounds in wastewater (chlorine or iodine demand). It appears that the iodine demand of wastewater is about 7-10 times higher than it is for chlorine. In order to reduce dosage for equivalent bacterial kills, reduced compounds, both organic and inorganic, would have to be oxidized. Since disinfection is normally practiced for surface discharge, effluent qualities would likely be high.

Site Conditions:

No general restrictions

Climatological:

No general restrictions; reaction rates are somewhat slower at lower temperatures requiring higher doses or larger contact times (usually both are excessive in small flows designs).

Treatment Capability:

BOD5: Perhaps a slight reduction by way of oxidation.
SS: None
Nitrogen: No oxidations; formation of choramines.
Phosphorus: No reactions.
Indicator Organisms/Pathogens: With proper dose-contact time, water quality objectives are achievable ( $<$ 100 fecal coli/100 mL). Virus or cyst destruction will require substantially higher doses of chlorine (free) or iodine than for bacterial cells (enough to overcome halogen demand).

Operation and Maintenance:

Labor: Only a small amount of time is required to maintain the simple solid-liquid feed halogen disinfection systems. Time is required for addition of disinfectant (~ 1-2 hr/yr for chlorine) and maintenance of feed equipment, pumps, etc. Tablet feeders occasionally become inoperable due to moist conditions.
Power: Power is required if pumping is necessary through the halogen feed system or if solution feeding of the halogen is employed.
Chemicals: Disinfectant; $NaOCl$, $CaOCl_2$, $Ca(OCl)_2$ or $I_2$ crystals
Residuals: None

Environmental Concerns:

Production of toxic chlorinated by-products - chlorinated organics.

Costs:

Installed Cost

| | |
|---|---|
| Chlorinator-Tablet Feed | $100-$150 |
| Iodinator | $100-$150 |
| Contact Tank and Plumbing | $400-$500 |

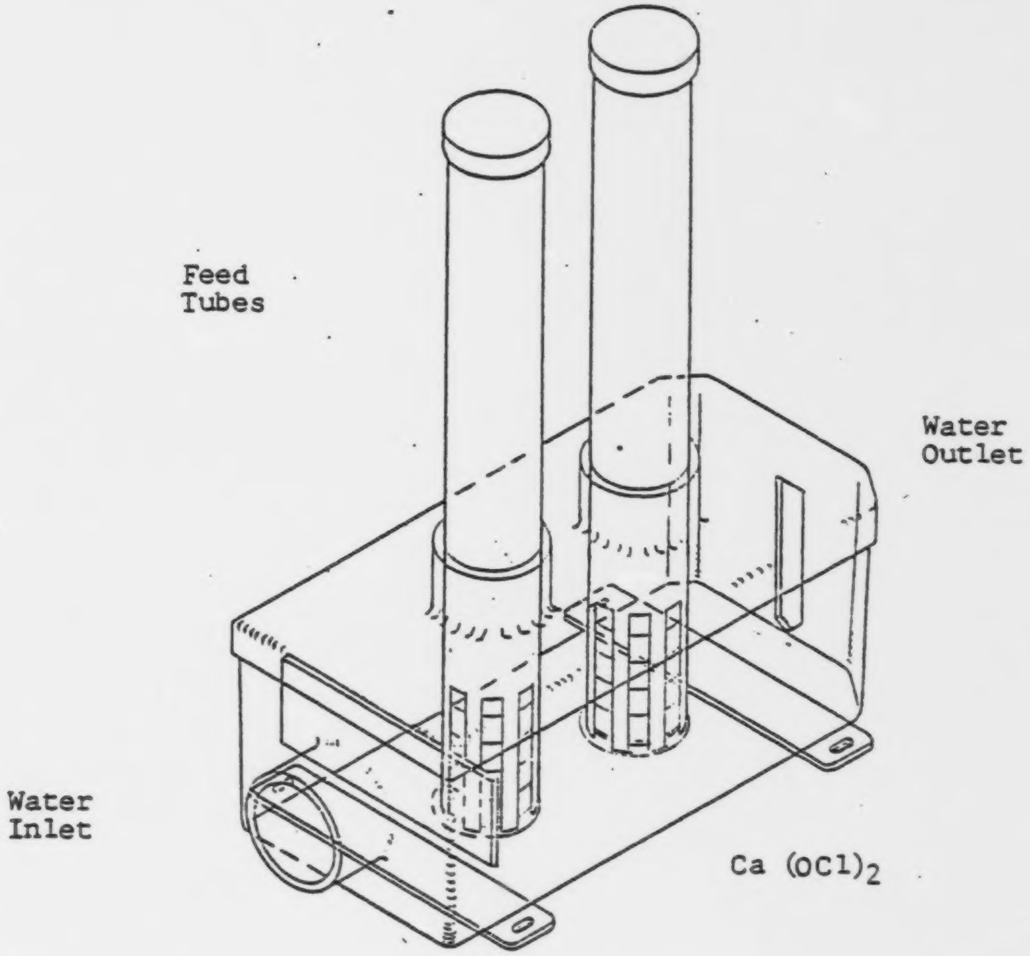
Operation and Maintenance

Labor (2 hr/yr) $10
Power - Depends on system pumping - very minor
Chlorine Tablets - $4.20/kg
Calcium Hypochlorite - 1.701 kg } 8 - $25/yr
Iodine Crystals - 6.00 kg

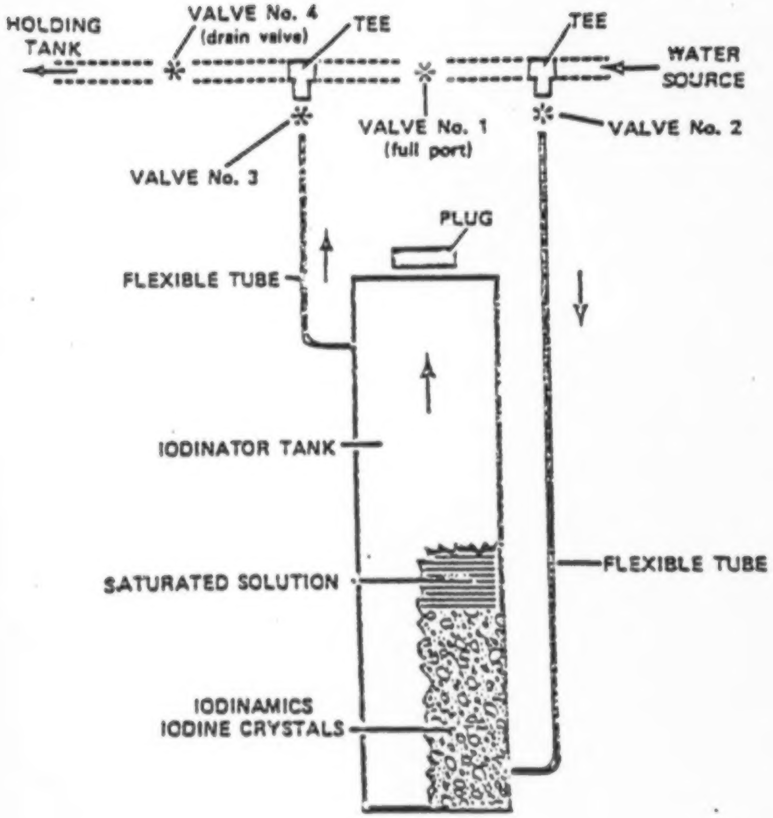
Source Materials:

Small Scale Waste Management Project (University of Wisconsin), 1978. Final Report, USEPA, Cincinnati, Ohio.

Stacked Tablet Chlorine Feed


Feed Tubes
Water Outlet
Water Inlet
Ca $(OCl)_2$

## Iodine Saturator


HOLDING TANK
VALVE No. 4 (drain valve)
TEE
TEE
WATER SOURCE
VALVE No. 1 (full port)
VALVE No. 2
VALVE No. 3
PLUG
FLEXIBLE TUBE
IODINATOR TANK
SATURATED SOLUTION
FLEXIBLE TUBE
IODINAMICS IODINE CRYSTALS

## Disinfection - Ultraviolet

Description:

Ultraviolet irradiation has been used for many years as a disinfecting medium. Only recently has it been applied to wastewater disinfection. Ultraviolet is germicidal in the wave length range of 230 to 300 nm with optimum efficiency at 257 nm. High intensity, low pressure mercury vapor lamps are normally used in these applications. The lamp is encased within a high transmission clear fused glass quartz sleeve both to protect the lamp and to maintain an optimum lamp temperature (105° F). Burning hours for lamps are variable normally ranging from 7500-12500 hours. Disinfection requirements for UV are based on total exposure of the liquid to the UV light energy and are expressed as microwatt seconds per square centimeter. USPHS minimum exposure requirements for drinking water are 16,000 mw sec/cm$^2$. Calculations of actual exposure are based upon the energy, time of exposure and surface area. Energy at the microorganism is estimated on the basis of the transmissibility of the water where transmissibility is an exponential function of the depth of water and the absorption coefficient of the water ($t = e^{-ad}$). Most UV systems are equipped with intensity meters as well as automatic cleansing devices to maintain the quartz tube.

Applicability:

Wastewater Influent Characteristics:

Volume: Limited only by site and UV equipment available.

Pretreatment: Since energy transmission is a function of wastewater absorbance, pretreatment of wastewater is paramount. Normally turbidities and color should be less than 10 ppm which is normally obtainable with intermittent filtration of the wastewater.

Site Conditions: No restrictions

Climatological Conditions: No restrictions

Treatment Capability:

$BOD_5$: Some $BOD_5$ may be reduced by UV treatment of filtered effluents.
SS: Some SS reduction may be achieved in UV treatment of filtered effluents.
Nitrogen: No changes
Phosphorus: No changes

Indicator Organisms/Pathogens: Depending upon total exposures, pathogens and indicator organisms may be reduced to acceptable levels by UV irradiation.

## Operation and Maintenance Requirements:

Labor: Major maintenance requirements involve cleansing of the quartz enclosures (may be automatic), checking for lamp intensity (may be automatically metered) and infrequent unscheduled maintenance on mechanical parts. Six month check ups are normally sufficient on small flows applications.
Power: Electrical power is required. For continuous operation, field studies indicated about 1.5 kwhr/day were required for a 15 w lamp installation (flow rates 2-4 gpm). At intermittent operation (70 minutes per day) only 2.2 kwhr/mo were required.
Chemicals: None required
Residuals: None produced

## Environmental Concerns:

Power consumption

Health hazard due to pathogen discharge when lamp inoperable at proper range

## Costs:

| | |
|---|---|
| Installed Costs | |
| UV Sterilizer | $750-900 |
| Staging Tank | $300-450 |
| Operation and Maintenance | |
| Labor ( 10 man hrs/yr) | $40-60/yr |
| Power (1.5 kwhr/d max) | $20/yr |

## Source Materials:

Oliver, B.G. and J.H. Carey, 1976. "Ultraviolet Disinfection: An Alternative to Chlorination," J. Wat. Poll. Cont. Fed., 48, 2619.

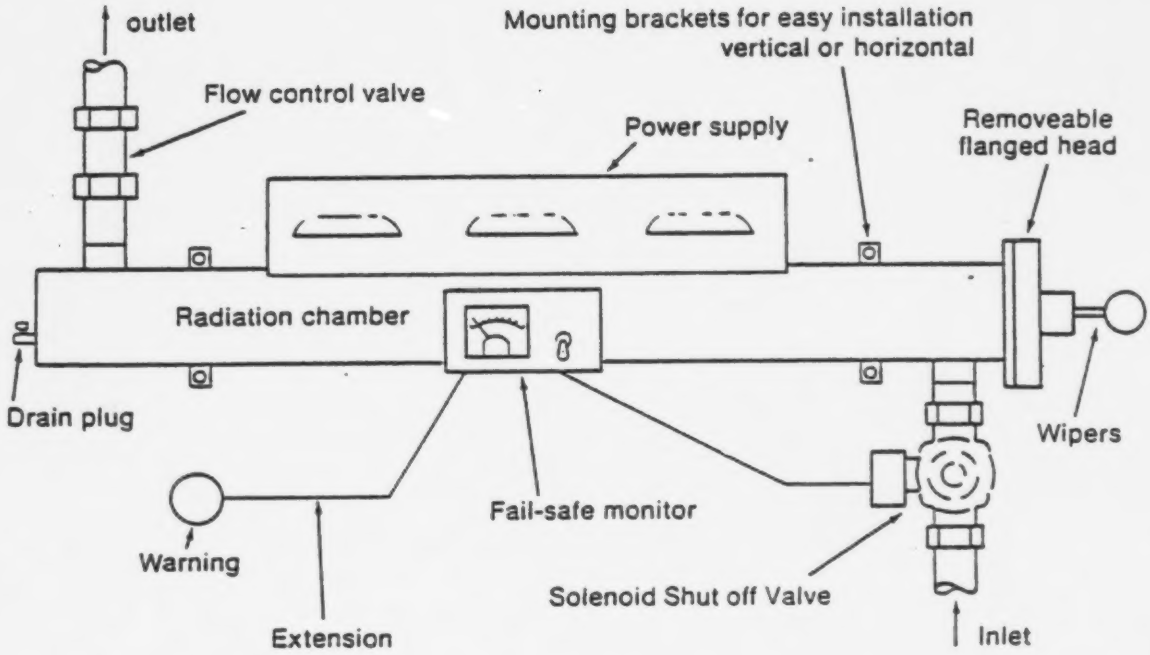
Jepson, J.D., 1968. "Some Notes on Ultraviolet Disinfection of Small Rural Supplies," Water Treatment Exam, 3, 205.

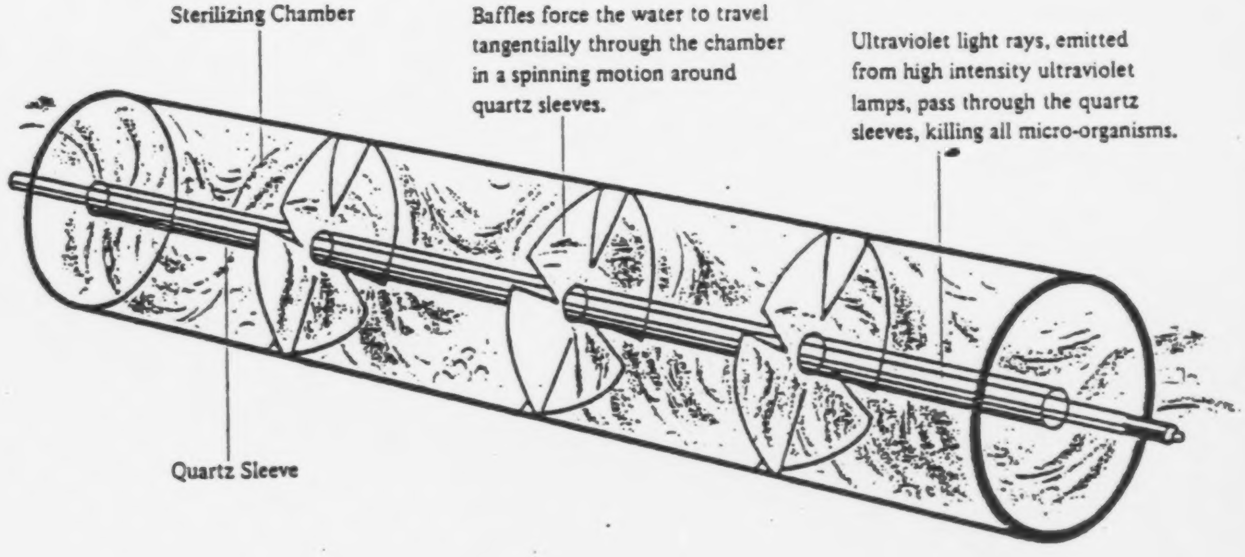
Stiff, F.R., 1971. "The Disinfection of Industrial and Potable Water Supplies Using UV Irradiation," Chem and Ind, 1, 116

Oliver, B.G. and E.G. Cosgrove, 1975. "The Disinfection of Sewage Treatment Plant Effluents Using UV Light," Can. J. Chem. Eng., 53, 170.

Huff, C.B., et al., 1965. "Study of Ultraviolet Disinfection of Water and Factors in Treatment Efficiency," Pub Health Rep, 80, 695.

Small Scale Waste Management Project (University of Wisconsin), 1978. Final Report, USEPA, Cincinnati, Ohio.


outlet
Mounting brackets for easy installation vertical or horizontal
Flow control valve
Power supply
Removeable flanged head
Radiation chamber
Drain plug
Wipers
Fail-safe monitor
Warning
Solenoid Shut off Valve
Extension
Inlet


Sterilizing Chamber
Baffles force the water to travel tangentially through the chamber in a spinning motion around quartz sleeves.
Ultraviolet light rays, emitted from high intensity ultraviolet lamps, pass through the quartz sleeves, killing all micro-organisms.
Quartz Sleeve

Typical sterilizers employ one to twelve lamps per sterilizing chamber.

## Nutrient Removal

Description:

There are a variety of processes which have been developed to remove specific nutrients from wastewater. A number of these processes are applicable to small flows wastestreams but there is very little data on long-term field applications of these systems. Table 1 summarizes selected processes for the removal of phosphorus whereas Table 2 summarizes nitrogen removal schemes. Likely flowsheets available for treatment of small flows wastewater appear in Tables 3 and 4.

Applicability:

Depends on system flowsheet

Treatment Capability:

Phosphorus: Variable; 50-95% reduction
Nitrogen: Nitrify: 85-95%
Nitrogen removal variable: 70-99%
Other Pollutants: Dependent upon system

Operation and Maintenance:

See Tables 1 and 2

Environmental Concerns:

Some processes energy intensive

Some processes produce concentrated residues

Air pollution ($NH_3$ stripping)

Costs:

Costs are highly variable dependent upon system. Little good data yet available on long-term field applications.

Source Materials:

Small Scale Waste Management Project (University of Wisconsin), 1978. Final Report, USEPA, Cincinnati, Ohio.

Brondes, M., 1977. "Effective Phosphorus Removal by Adding Alum to Septic Tank," J. Wat. Poll. Cont. Fed., 49, 2285

Process Design Manual for Phosphorus Removal, 1976. USEPA Technology Transfer, EPA 626/1-76-001a.

Process Design Manual for Nitrogen Control, 1975. USEPA Technology Transfer.

Weber, W.J., 1972. *Physiochemical Process for Water Quality Control*, Wiley-Interscience, New York, NY.

Smith, J.J., 1978. "The Feasibility of Using Clinoptilolite for Removal of Ammonia From Septic Tank Effluent," Independent Study Report, University of Wisconsin, Madison Wisconsin.

Detweiler, J.C., 1978. "Phosphorus Removal on Alumina as Applied to Small Scale Waste Treatment," Independent Study Report, University of Wisconsin, Madison, Wisconsin.

## Table 1

## Phosphorus Removal Flowsheets

| General Methods | System | Effectiveness | Comments | Status* |
|---|---|---|---|---|
| **Biological** | | | | |
| Modified Activated Sludge | Package Plants | Variable | Labor/Energy Intensive | Unlikely |
| Activated Algae | Special Reactor | 70-95% | Labor/Energy Intensive<br>Untested in Field | Unlikely |
| Lagoons | - | Up to 80% | Seasonal; Undependable | Possible |
| **Chemical Precipitation** | | | | |
| Iron, Aluminum (Lanthanum) Salts With or Without Polymers | Dosing to Septic Tank | 85-90% From Toilet | 10 Day Detention Time, Al; $P \sim 2.0$<br>Residue Disposal | OK |
| | Dosing Following Septic Tank | Up to 90% | Labor, O/M Intensive<br>Variable Success<br>Residue Disposal | OK |
| | Dosing in Biotreatment | Up to 90% | Labor/Energy Intensive | Unlikely |
| | With Filtration | Up to 95% | Labor/Energy Intensive | Unlikely |
| **Surface Chemistry** | | | | |
| Ion Exchange | Beds or Columns | 90-99% | Resins Available<br>Costly, Residue | Possible |
| Sorption Processes | | | | |
| Calcite | Beds or Columns | Poor, Variable | Organic Interference | Unlikely |
| Alumina | Beds or Columns | 90-99% | Several Sizes Available, Costly, Residue | Possible |

* Acceptable status for small flows application.

Table 1 (Continued)

| General Methods | System | Effectiveness | Comments | Status* |
|---|---|---|---|---|
| Segregation | | | | |
| Eliminate Laundry Detergents | - | 50% | 0.5% P Detergents Available | OK |
| Grey Water Separation | - | 60-80% P In Grey Water<br>20-40% P In Black | In Combination With Treatment; Non-Carriage Toilets | OK |

---

* Acceptable status for small flow applications.

## Table 2

## Nitrogen Control Flowsheets

| General Methods | System | Effectiveness | Comments | Status* |
|---|---|---|---|---|
| **Biological** | | | | |
| Nitrification | Biological Oxidation Package Plants | 85-95%<br>(To $NO_3^-$) | Labor/Energy Intensive | OK<br>($NH_4$ Removal) |
| Denitrification | Biological Conversion (Anaerobic) - Follows Nitrification (Susp. Growth or Fixed Film) | 80-95%<br>(To $N_2$) | Labor/Energy Intensive<br>Methenal Addition | Possible |
| **Physical/ Chemical** | | | | |
| Ammonia Stripping | pH Adjustment, Stripping Tower or Pond | 90-95% | Labor/Energy Intensive<br>Air Pollution<br>Temperature Sensitive | Unlikely |
| Ion Exchange | Cationic Exchange - $NH_4$<br>Anionic Exchange - $NO_3$ | 90-99% | Energy Intensive<br>Costly<br>Residue | Possible |
| **Segregation** | | | | |
| Grey Water | Use of Non-Water Carriage or Very Low Flow Toilets | 70-99% | Residue<br>Grey Water Treatment | OK |

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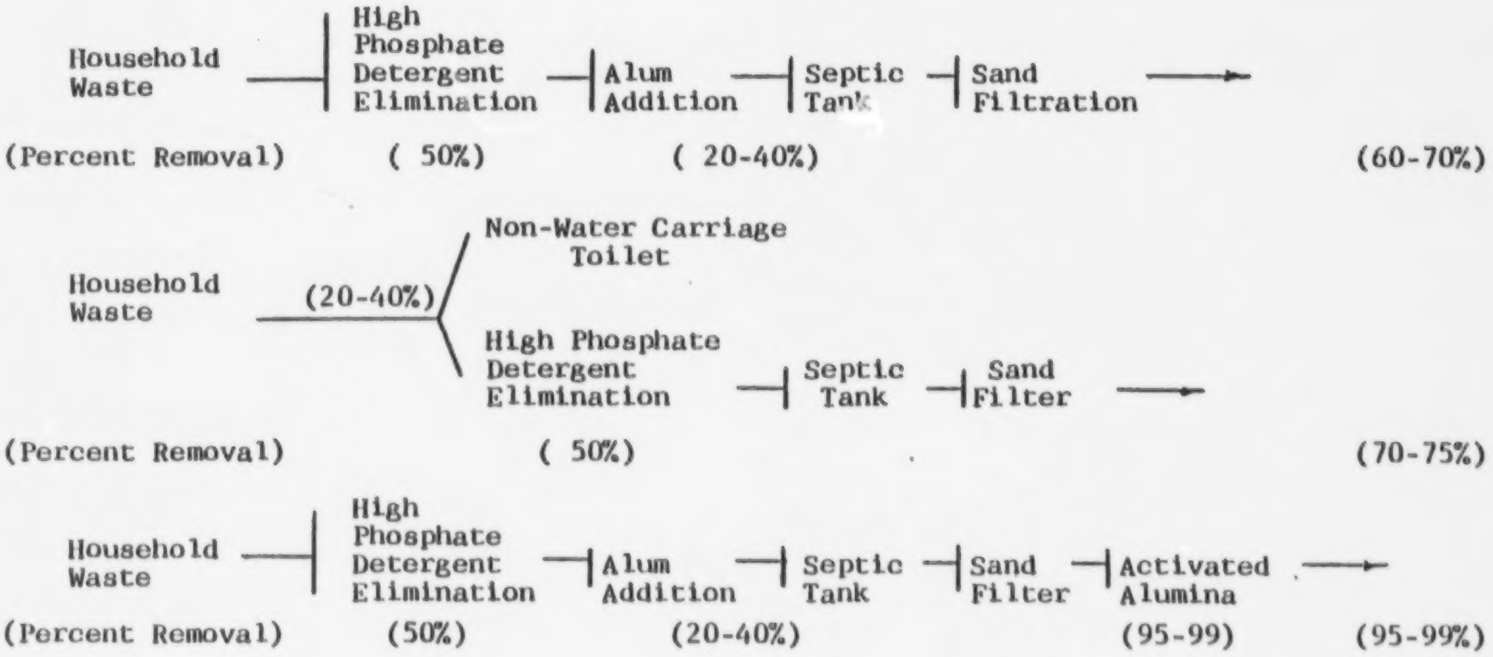
* Acceptable status for small flow applications.

## Table 3

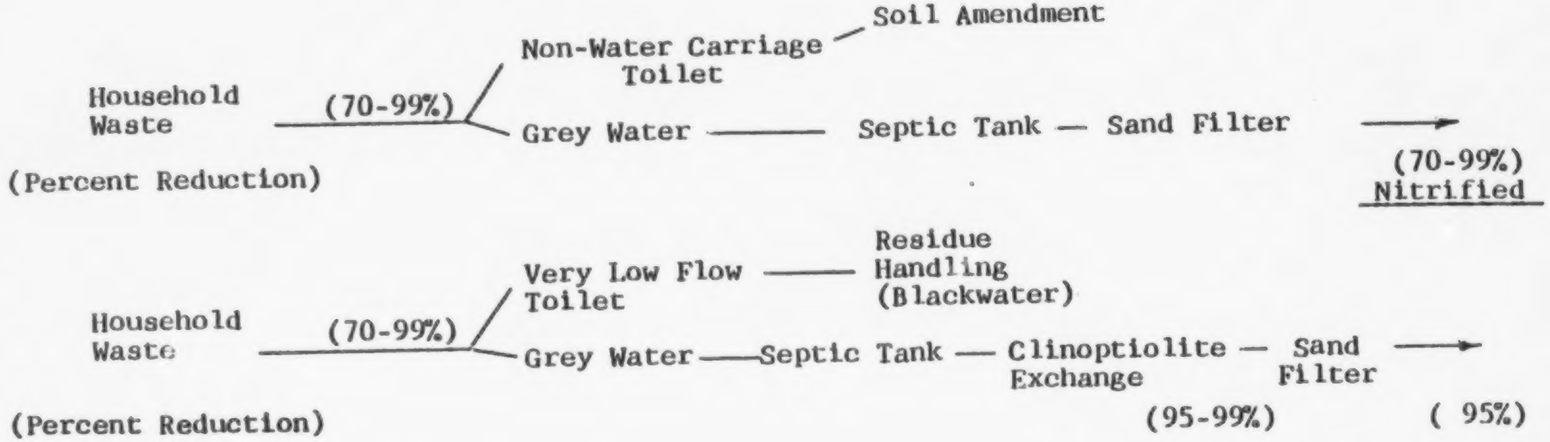
### Likely Flowsheets for Small Flows
### Phosphorus Removal


Household Waste
High Phosphate Detergent Elimination
Alum Addition
Septic Tank
Sand Filtration
(Percent Removal)
( 50%)
( 20-40%)
(60-70%)
Household Waste
(20-40%)
Non-Water Carriage Toilet
High Phosphate Detergent Elimination
Septic Tank
Sand Filter
(Percent Removal)
( 50%)
(70-75%)
Household Waste
High Phosphate Detergent Elimination
Alum Addition
Septic Tank
Sand Filter
Activated Alumina
(Percent Removal)
(50%)
(20-40%)
(95-99)
(95-99%)

## Table 4

## Likely Flowsheets for Small Flows

## Nitrogen Control


Household Waste
(70-99%)
Non-Water Carriage Toilet
Soil Amendment
Grey Water
Septic Tank
Sand Filter
(70-99%) Nitrified
(Percent Reduction)
Household Waste
(70-99%)
Very Low Flow Toilet
Residue Handling (Blackwater)
Grey Water
Septic Tank
Clinoptiolite Exchange
Sand Filter
(Percent Reduction)
(95-99%)
( 95%)

## Evapotranspiration

### Description:

A method used for the disposal of pretreated wastewater to the atmosphere via evaporation and plant transpiration at sites where soils are unsuited for conventional subsurface soil absorption systems. The bed consists of a lined or unlined excavation partially filled with coarse rock containing distribution piping. Clean, uniform sand ($D_{50} = 0.1$ mm) covers the gravel to the ground surface. Pretreated wastewater is discharged into the rock and the waste is raised to the ground surface by capillary action of the fine sand. Evaporation takes place at or near the surface of the bed. Plant life may be used to raise the water from the area of the root zone to the leaves to be removed by transpiration. Lined beds are used in areas where groundwater or surface water contamination is a concern. Unlined beds are used in areas where soil percolation is insufficient as the sole means of disposal. Maximum loading rates in the U.S. for lined beds serving permanent homes is 0.08 gpd/ft$^2$.

### Applicability:

Volume: Size is limited by site conditions only. Principal application has been for single family dwellings and small commercial establishments.

Pretreatment: Sedimentation, conventionally provided by septic tanks.

### Site Conditions:

Soils/Geology: None
Topography: None, though flat to gently sloping sites preferred.
Setback Distances: Check local codes.

### Climatological Conditions:

Pan evaporation rates minus precipitation must exceed zero for all months.

### Treatment Capability:

Lined beds discharge water vapor only while unlined systems would discharge water to the groundwater at a quality similar to that found below subsurface soil absorption systems.

### Operation/Maintenance Requirements:

Labor: None
Power: None
Chemicals: None
Residuals: Salts will accumulate in the bed which may require periodic removal.

## Environmental Concerns:

Lined beds prevent discharge of wastewater except via the atmosphere.

Groundwater or surface water is not recharged.

Low energy requirements.

## Costs:

Construction: \$1.00 to \$1.50/ft$^2$

Maintenance: -

## Comments:

Lined beds may be successfully used for permanent homes in Arizona, California, Colorado, New Mexico, Nevada, Texas, and Utah.

Lined beds may be successfully used for summer homes in Idaho, Kansas, Montana, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, Washington, and Wyoming.

The use of evapotranspiration beds should be coupled with flow reduction methods at the wastewater source.

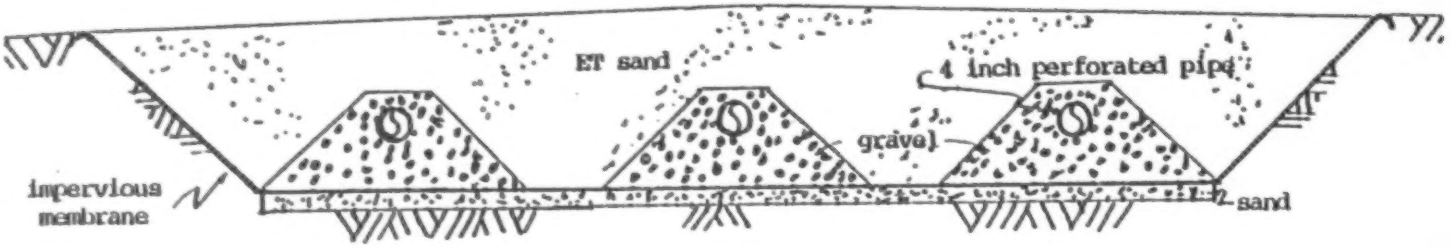
During periods of heavy rainfall, seepage may occur from the bed.

## Source Materials:

Bennett, E.R. and K.D. Linstedt, 1978. "Sewage Disposal by Evaporation - Transpiration." U.S. Environmental Protection Agency, Cincinnati, Ohio.

Ward, J.D., 1977. "Evaporation of Wastewater From Mountain Cabins." Environmental Resources Center, Colorado State University, Fort Collins.

National Oceanic and Atmospheric Administration (NOAA), Climatological Data, published monthly for each state.


ET sand
4 inch perforated pipe
gravel
impervious membrane
sand

Typical ET Bed Cross-Section (Bennett and Linstedt, 1978)

# "ON-SITE WASTEWATER TREATMENT ALTERNATIVES"

Questions and Answers Following Presentations by
Dr. William C. Boyle and Mr. Richard J. Otis
University of Wisconsin-Madison

AUDIENCE: This question has to do with the use of underdrains. I noticed that you listed on one of the slides the possibility of slight modifications with drains and I assumed that this might imply underdrains. This makes a difference between disposal and treatment and I see it as an important distinction to be made for a small community as well as for private systems. I guess my question is do you have the experience of trying to control or permit the discharge of individual treatment systems in the sense of ground treatment?

MR. OTIS: You mean, control the underdrainage. Well, I would comment on what we've done in Wisconsin first. From the single home standpoint, we don't know enough about these underdrain systems. What we've generally done is worked with the curtain drains where you're just draining the groundwater trying to drop the water table sufficiently so that you have an adequate unsaturated depth between the infiltrative surface and the water table. There we're just discharging clear groundwater, but there have been some problems with that in that dropping the water table too low, we've changed the gradient and we're actually getting effluent back out the drains. So we're doing some more work on that. Completely underdraining a system we've generally avoided because of this problem of what do you do with this liquid that comes out? Is it suitable for surface water discharge? How are we going to control it? And then if something does go wrong, what kind of problems are we going to have with it?

When you're talking about a community application, generally if you're going to have to underdrain a system, I guess I would look at another alternative because then you're handling a large volume of water. Your soil conditions aren't optimal and you can run into a lot of problems, but on an individual basis it does offer an alternative. We do need to know some more about it.

AUDIENCE: I have two questions about what you said. The first question refers to what you called a long term percolation rate referring to after the bed has been established and you get a certain amount of blocking. How would something like that really be determined? Is that just sort of an engineering judgment or based on soil data or what? It certainly is something that's difficult to get a handle on.

MR. OTIS: Now, the question was how did we come upon those long term infiltration rates. It is a difficult process. What we had to do....essentially involved the crust test which we developed, where we could actually measure the unsaturated hydraulic conductivity of different soils. It's a complicated test, takes several days to run. What we did was to go out to a number of areas where we had existing systems installed in the ground that had been functioning for several years, 8 to 12 year. We ran the hydraulic conductivity test in the soil adjacent to the system, and then we went in under the bed and actually measured the moisture potential. So we knew the hydraulic conductivity versus the moisture potential from our previous tests and then we knew the moisture potential underneath the bed, and from that we calculated on what the hydraulic conductivity would be through that clogging mat. So, that's the way we arrived at that.

AUDIENCE: That doesn't strike me as the kind of thing that will be done for every location in the community, certainly, and probably not even for the whole community based on one or two samples.

MR. OTIS: Yes, this is not something that is intended to be that way. You'll find that soil materials may vary in name, but their physical characteristics don't change all that much and you can group soils.

AUDIENCE: So we can get data through the University or there is data available that could give you at least an idea of what's your soil type, how it should respond.

MR. OTIS: Yes, in Wisconsin we have over 400 soil series and we've been able to group them in only four groups and we have a hydraulic conductivity for each one of them.

AUDIENCE: Dick, what would you expect the life to be on these soil absorption systems? Obviously, if we're going to be comparing that to other alternatives based on 20-year planning period something ought to be factored in there to allow for salvage at the end of the 20 years or replacement at the end of some shorter period.

MR. OTIS: You caught me. I was avoiding the lifetimes of these systems, which is very important if you're talking about the economic analysis of them for homes or small communities. Unfortunately, we don't know enough about the lifetimes but I am confident that these systems will have a lifetime of 20 years or more. We have a number of things that are going for us right now. Number 1, you can go with alternating beds. That extends the life considerably, and you're always rejuvenating the unused bed. There's also the hydrogen peroxide which in some cases will provide you the increase of life. If clogging becomes severe, you can open it up that way.

The pressure distribution idea, the dosing, the better construction and design and siting procedures have upgraded the technology considerably to the point where I think you can count on at least a 20 year life out of these systems.

The important thing, of course, is the actual construction and the maintenance. If it's not constructed properly, even though you followed the design, if they're in there when the soil is bad and it's too wet, or the proper fill material isn't selected, you're going to have problems. But we're counting on at least a 20 year life and hopefully much more.

AUDIENCE: Considering the costs involved here for these kinds of systems, and also the fact that it will take up a good part of your backyard or front yard like that one type of bed, is it safe to say that this is not a very feasible alternative for community-wide application?

AUDIENCE: You know, in the design of a land treatment system, you go to considerable lengths to try to protect your ground water, by design. It seems to me that the primary concern here is to get the water into the soil and through the soil, and I think there's a bit of an inherent danger in that you can cause some serious ground water degradation, if you have relatively concentrated numbers of septic systems like this. And also, there is some evidence that virus and even some bacterial organisms are transferred to ground water through land treatment irrigation systems. Now, it would seem to me that, I believe, you gave an indication that there was no worry about virus here, a while ago -- maybe you didn't. I got the impression that you weren't too concerned about viruses. Maybe not, but it seems to me that there is even more potential here possibly for viral transfer on the ground water than there would be in the land treatment system.

MR. OTIS: Okay, I'm not sure about that last statement, why would you feel that way, because, I didn't mean to emphasize absorption over treatment, because those are two of our objectives, of course. We want to get it into the soil, but once in, we're going to get it treated, and I think in the past that's been neglected. We've addressed that question pretty well. But we find that when you're dealing with soil absorption fields, you are not getting many fecal bacteria through, certainly by the time it gets through three feet, almost all of them are removed. The same is true of virus. When you make comparisons between land treatment and subsurface soil absorption, you have to be careful, because you're talking about really two different things. And in some of those land treatment systems, you're really putting a lot of water on it, because that surface is exposed, you're not getting that clogging mat to develop that you are to the degree that you are in the subsurface field. And so at some times you're getting saturated flow, and a lot of these land systems are located on coarse material, because you can keep the system as small as possible that way. And so then, it becomes even more a greater potential for ground water contamination. Now, when you're dealing with domestic waste, you're really only concerned about the bacteria, the virus, and some of your nutrients. So, even in areas where you might have very dense development, there's really not that much concern. Now, you might have concern with the nitrates. I'm not convinced nitrates are a problem. But some people are, so they're concerned about the build up of those above 10 mg per liter. That would be the only thing that I could think of in these densely populated areas. But if that were a concern, cluster the systems together and take it off someplace else. And put it in one spot. The important thing is you're talking about two different things. And you can't really compare them.

AUDIENCE: Do you feel that there can be a reduction in the drain field if you use the aerobic systems?

DR. BOYLE: We have not found that you can. There's some suggestion that in sand soil it might help, but in the finer soils we have just not found any evidence that there's any advantage to producing a real high quality effluent as far as reducing the size of the drain field. Any other questions?

AUDIENCE: Was this perhaps because the effluent wasn't treated to the degree that might have given better results?

DR. BOYLE: Well, actually what we did was to look at septic tank effluent and aerobically treated effluent. We also looked at sand filtered effluent, and then we prepared a bunch of samples with tap water and glucose. We found all of them flushed through the soil at the same rate. The mechanisms of clogging were different, but the rates were about the same. We decided there was more of a hydraulic problem than there was of a wastewater problem. Now, you can have gross contamination and really clog it up in a hurry. Don't get me wrong, you'll have rapid clogging. If you put a lot of oils and grease in there.

AUDIENCE: Would you say there would be a difference between clean water and wastewater then?

DR. BOYLE: Very little difference in the soil, very little difference. Now, if anyone is really interested in doing this on a large scale basis it whould probably be done in the field for a long period of time. We did not do this, because we just didn't see the economic justification for it. You saw how much those processes cost. Even if you were able to have a quarter of the size of your soil field, it was pretty hard to justify the expenditure of that kind of money for that purpose.

# ALTERNATIVES FOR THE TREATMENT AND DISPOSAL OF RESIDUALS FROM ON-SITE WASTEWATER SYSTEMS

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# INTRODUCTION

Rural and suburban populations which rely on on-site wastewater treatment and disposal systems are confronted with the problem of managing residuals generated from these systems. In some areas, finding environmentally sound techniques for disposal of these sludges has been exceedingly difficult. The purpose of this paper is to review the technologies available for handling this material in a safe and effective manner. While some of the alternatives presented represent well demonstrated, viable options, other techniques discussed may not yet have been implemented as septage handling alternatives. However, they are included in this discussion because they offer potentially viable solutions to the problem of on-site residuals management.

In the presentation of individual alternatives for on-site residuals treatment/disposal, each summary will be divided into the following sections:

a. Description of Process
b. Design Parameters or Considerations
c. Advantages/Disadvantages
e. Bibliography

Only summary descriptions of processes, design criteria and costs are presented in this paper. For more detailed information, the reader is urged to consult the references listed at the end of each section.

# RESIDUALS GENERATION RATES AND CHARACTERISTICS

Proper maintenance of any on-site wastewater treatment system requires periodic removal of accumulated by-products or residuals. In a general sense, this could include septage from septic tanks, sludge from aerobic treatment units, scum from sand filters, waste from holding tanks, humus from a compost toilet, ash from an incinerating toilet, sludge from oil-recirculating toilet systems, etc. A partial list of residuals generated from on-site systems is given in Table 1. By far the most common waste material generated from on-site systems is septic tank sludge, or septage. Consequently, the bulk of this discussion will be oriented toward techniques for proper management of this waste, while only cursory consideration will be given to other on-site residuals.

Observed pumping frequencies for septic tanks vary considerably. Theoretically, the frequency of pumping should be a function of the septage accumulation rate. For homeowner-maintained systems, the frequency may vary from once per year to once every ten years or more. To minimize the potential for absorption field failure due to carry over of solids from the septic tank, it has been suggested that the contents of the septic tank be pumped out every two to four years. Aerobic on-site treatment units generally require waste sludge removal at least yearly.

Several techniques may be employed to estimate the septage generation rate for a particular area. These are briefly discussed below:

1. Septage Haulers - If accurate records are kept by the septage hauler, this may provide reasonable estimates of annual septage production rates.

2. Number of Homes - Assuming that the number of dwellings using septic tanks is known, a tank volume (1000 gal.) and pumping frequency (every 3 or 4 years) can be assumed, allowing simple calculation of generation rates.

   $$\text{e.g. } \frac{500 \text{ homes} \times 1000 \text{ gal}}{4 \text{ years}} = 125{,}000 \text{ gal/year}$$

   This may yield a conservative estimate for generation rates currently experienced. However, it is reasonable to believe that if a public entity (management district) is to assume responsibility for operation and maintenance, then septic tanks will be pumped more often than is currently practiced by most homeowners.

3. Population - Assuming a per capita septage production of 60-80 gal/cap/yr, a crude estimate can be made of the septage generation rate.

Generation of septage is often highly seasonal, particularly in northern climates. Frost penetration may preclude septic tank pumping except in emergencies. Consequently, in such areas, the rate of septage generation

## TABLE 1

## RESIDUALS GENERATED FROM ONSITE WASTEWATER SYSTEMS (1)

| Residual | Source | Frequency of Removal | Characteristics | Disposal[a] |
|---|---|---|---|---|
| Septage | Septic tank | 2 to 5 yr | High BOD and SS; odor, grease, grit, hair, pathogens | Pump out by professional hauler for off-site disposal. |
| Sludge | Aerobic unit | 1 yr | High BOD and SS; grease, hair, grit, pathogens | Pump out by professional hauler for off-site disposal. |
| Sewage | Holding tank | week to months | Strong septic sewage; odor, pathogens | Pump out by professional hauler for off-site disposal. |
| Blackwater | Holding tank | 6 months-1 yr | High BOD and SS; odor, pathogens | Pump out by professional hauler for off-site disposal. |
| Recycle Residuals | Recycle systems | 6 months-1 yr | Variable depending on unit processes employed | Pump out by profesisonal hauler for off-site disposal. |
| Compost | Compost toilet;<br>large<br>small | <br>6 months-1 yr<br>3 months | Relatively stable, high organics, low pathogens | Homeowner performs onsite disposal; garden burial. |
| Ash | Incinerator toilet | weekly | Dry, sterile, low volume | Onsite burial by homeowner or disposal with rubbish to landfill |
| Scum | Sand filters | 6 months | Odor, pathogens, low volume | Onsite burial by homeowner or off-site disposal |

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[a] Approval by state or local regulatory agency necessary.

peaks during the spring months and continues to be significant during the summer and fall, dropping off considerably during the winter. Septage loading patterns experienced at the Lebanon, Ohio Sewage Treatment Plant are shown in Figure 1.

Septage is a highly variable, high strength organic slurry characterized by an obnoxious odor, resistance to settling and dewatering, potential to foam, and often significant content of grease, grit, and hair. Typical characteristics are presented in Table 2. Of particular importance as a design consideration is the highly variable nature of this waste, some parameters varying by two orders of magnitude. The concentration of metals is considerably lower than that of sewage sludge; consequently, heavy metals in septage do not constitute a serious problem. However, septage often contains material which is capable of fouling pumps and other equipment (valves, probes, etc.) This has been identified as grit and sand (abrasive effects on equipment), grease (pipe and valve clogging) and hair (fouling of impellers, blinding of screening devices). Although these characteristics are undesirable from a materials handling standpoint, the major reason for providing adequate septage treatment and disposal techniques is the potential threat to public health. As shown in Table 3, significant numbers of indicator organisms and pathogens may be found in septage. In addition, several parasites have been identified.

For most municipalities, residuals generated from other types of on-site systems would not be of major concern because 1) the number of such units would probably be small in relation to septic tanks 2) these wastes would probably be treated in conjunction with septage rather than on a batch load basis.

Sludges from aerobic treatment units are similar to secondary sewage sludges found in activated sludge plants. Unfortunately, little characterization data is available. Although some problems may be associated with handling this material (hair, grit, grease), in general, it is a more stabilized, less offensive waste. Indiciator organisms are likely to be found in significant quantities, however.

For particularly restrictive site conditions, holding tanks, often in conjunction with in-house flow reduction devices, are sometimes employed. This results in the accumulation of a relatively strong sewage. Variations of this concept include holding tanks for blackwater (toilet wastes) only, possibly used with a low-flush toilet. Pumping frequency will be dependent on water use, and holding tank capacity. The strength of the wastes will largely be a function of user habits and degree of flow reduction practiced. In general, such wastes do not pose any particular problems that are not common to septage handling. The exception to this may be sludge pumped from the holding tanks of oil-recirculating toilets. In this case, the oil-covered sludge may be unsuitable for conventional treatment alternatives.

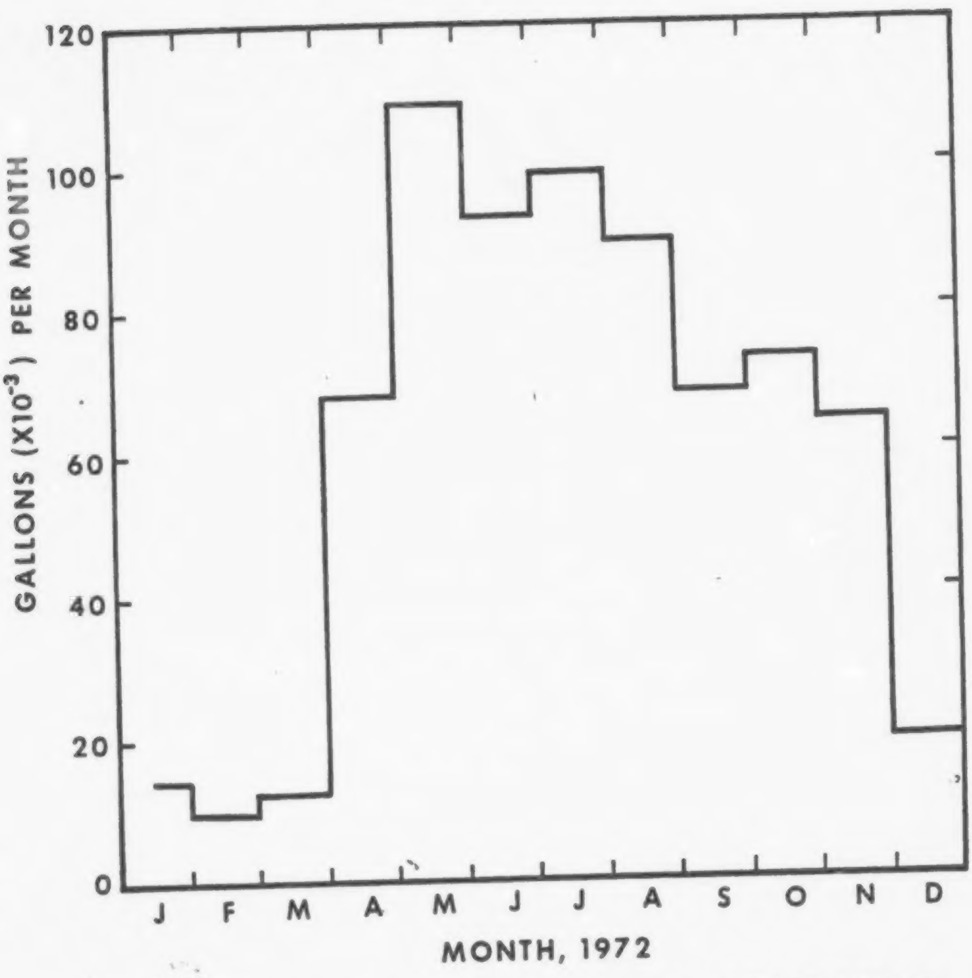

Figure 1. SEPTAGE LOADING PATTERN AT LEBANON

## TABLE 2

## CHARACTERISTICS OF DOMESTIC SEPTAGE

| Parameter | Mean Value mg/l |
|---|---|
| Total Solids | 22,400<br>11,600<br>39,500 |
| Total Volatile Solids | 15,180<br>8,170<br>27,600 |
| Suspended Solids | 2,350<br>9,500<br>21,120<br>13,060 |
| Volatile Suspended Solids | 1,770<br>7,650<br>12,600<br>8,600 |
| BOD | 4,790<br>5,890<br>3,150 |
| COD | 26,160<br>19,500<br>60,580<br>24,940<br>16,268 |
| pH | 6-7 (typical) |
| Alkalinity ($CaCO_3$) | 610<br>1,897 |
| TKN | 410<br>650<br>820<br>472 |
| $NH_3$-N | 59<br>100<br>120<br>92<br>153 |

TABLE 2 (continued)

| Parameter | Mean Value mg/l |
|---|---|
| Total Phosphorus | 190 |
| | 214 |
| | 172 |
| | 351 |
| Grease | 3,850 |
| | 9,560 |
| Aluminum | 48 |
| Arsenic | 0.16 |
| Cadmium | 0.1 |
| | 0.2 |
| | 9.1 |
| Chromium | 0.6 |
| | 1.1 |
| Copper | 8.7 |
| | 8.3 |
| Iron | 210 |
| | 160 |
| | 190 |
| Mercury | 0.02 |
| | 0.4 |
| Manganese | 5.4 |
| | 4.8 |
| Nickel | 0.4 |
| | <1.0 |
| | 0.7 |
| Lead | 2.0 |
| | 8.4 |
| Selenium | 0.07 |
| Zinc | 9.7 |
| | 62 |
| | 30 |

## TABLE 3

## INDICATOR ORGANISM AND PATHOGEN CONCENTRATIONS IN DOMESTIC SEPTAGE

| Parameter | Typical Range counts/100 ml |
|---|---|
| Total Coliform | $10^7$ - $10^9$ |
| Fecal Coliform | $10^6$ - $10^8$ |
| Fecal Streptococci | $10^6$ - $10^7$ |
| Ps. aeruginosa | $10^1$ - $10^3$ |
| Salmonella sp. | <1 - $10^2$ |
| Parasites<br>Toxacara, Ascaris lumbricoides,<br>Trichuris trichiura,<br>Trichuris vulpis | Present |

Septage, a mixture of sludge, fatty materials, and wastewater removed during the pumping of a septic tank, is a difficult and undesirable material to handle. It is often highly odoriferous and may contain significant quantities of grit, grease, and hair that may make pumping, screening, or settling difficult. Of particular importance is the high degree of variability of this material, some parameters differing by two or more orders of magnitude. This is reflected to some extent by the variability in mean values presented in Table 9-2. For this reason, septage should be characterized prior to selection of design values.

In general, the heavy metal content of septage is low relative to municipal wastewater sludge, although the range of values may be wide. Because of the low metal content, application rates may be based on nitrogen rather than metal loading for land application systems.

Table 3 presents typical concentration ranges for indicator organisms and pathogens in septage. These values are not unlike those found for raw primary wastewater sludge. It is evident that septage may harbor disease-causing organisms, thus demanding proper management to protect public health.

# TREATMENT AND DISPOSAL ALTERNATIVES

# FOR

# ON-SITE WASTEWATER RESIDUALS

## GENERAL DESIGN CONSIDERATIONS FOR SEPTAGE ALTERNATIVES

The alternatives for treatment and disposal of septage have some design requirements that are common to all of them. Certain alternatives may be more technologically sophisticated than others, but generally all of the processes require thorough investigation of the following design parameters before proceeding to the detailed designs.

### Volume and Quality of Septage to be Handled

The most important data for designing any septage treatment and disposal system is the quantity and quality of the waste to be processed. This information is particularly important for selecting a site, sizing and selecting equipment and for determining the impact on existing processes and the environment. Seasonal variation in septage generation is an important consideration.

### Climate

The effects of climate do not impact all of the alternatives but those that require soil manipulation (such as land application) or temperature control (such as composting) must consider climate in the design.

### Site Selection

Site selection is an important factor for all treatment and disposal alternatives. Site selection must consider size, soil type, geological configurations, slope, hydrology (depth to ground water, aquifer characteristics) proximity to dwellings, proximity to drinking water sources, and in some cases, intended use of crop.

### Septage Receiving Station

The receiving station should be designed so that it is easily accessible by the pumper trucks, provides coarse screening, and has adequate clean-up facilities (high pressure hose). Provisions should be made to ensure that accurate records are maintained. Holding tank capacity should be designed for a two day peak volume. Additional screening may be required to ensure pump protection.

### Site Work

All alternatives will require some degree of site work such as fencing, storage vessels, mixing vessels, access roads, pads, and laboratory facilities.

# LAND DISPOSAL ALTERNATIVES

## SURFACE SPREADING

### Description of Process

Application to the land surface is the most frequently used septage disposal method in the U.S. Surface spreading of septage is accomplished by the same techniques as municipal sewage sludge spreading. This may merely involve the septage pumping truck emptying the contents on the soil surface while driving slowly over the disposal site. This technique has low operation and maintenance requirements. A more controlled approach to surface spreading is to use a holding tank to receive septage loads when the soil is not suitable for accepting the waste. A special vehicle can then be used to spread the septage when weather and soil conditions are suitable.

Septage may be applied directly on plowed soil or on grassy areas. Odors can be a significant problem with surface spreading. In addition surface application may represent a potential health hazard if the septage has not been stabilized by one of the methods described under "Independent Septage Treatment Facilities". Several types of land spreading equipment can be used. The septage pumper truck can be equipped with a splash plate to spread out the area of application. For periods of wet weather, a truck can be equipped with flotation tires to prevent slippage. A large, centralized disposal area may use a tractor to pull a tank wagon equipped for liquid discharge. In such cases, holding facilities are necessary to allow filling of the tank wagon on a regular schedule.

### Design Parameters

The principal design factors for surface disposal are application rate, soil conditions, site location, and climate. Application rate and soil conditions are factors which control the area needed for the volume of waste to be handled. Site location is important for minimizing odors and run-off conditions. Crop cover is a factor in application rate based on nitrogen loading. Techniques for determining application rates for municipal sewage sludge have been developed in recent years and are applicable to land disposal of septage. Application rates for septage can be based on nitrogen loading or on heavy metal loading. Since septage is primarily a domestic waste, it is unlikely that yearly application rates would be determined by heavy metal loadings. An application rate based on annual nitrogen loading and nitrogen uptake by crops is the most likely design parameter for septage land disposal. Thus, the yearly application rate based on nitrogen loading could continue for several years until the maximum metal equivalent permitted for the site is reached. Excellent guidelines and basic design examples are presented in, "Guidelines for the Application of Wastewater Sludge to Agricultural Land in Wisconsin,"[1] and "Maine Guidelines for Septic Tank Sludge Disposal on the Land."[2] Application rates for different soils are based on an average value for nitrogen in septage; approximately 8 lb/1000 gal. Other design factors include the slope of the land selected for the disposal site, i.e., recommended < 8% slope.

The disposal site should be at least 300 ft. away from wells, springs, intermittent streams, streams, rivers, ponds, lakes, marine waters, and flood plains.

Holding facilities or a contingency septage disposal plan may be required where climatic conditions (frozen ground, snow cover) preclude land spreading.

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| No sophisticated process steps involved for disposal | Odors emitted while spreading and immediately after |
| Limited labor required | Spreading is restricted by periods of wet soil and frozen soil |
| Spreading equipment can be septage pumping truck with splash plate | Additional storage may be required to hold septage during inclement weather |
| Nutrients and water supplied to soil for growth of vegetation | Land slopes limited to < 8% |
| Costs usually quite low | Local health agency may require pretreatment for deodorization and pathogen disinfection |

## Costs for Surface Spreading

Although surface spreading of septage is practiced, there are no published data on costs for this alternative. However, there are considerable data available on the costs associated with surface spreading of municipal sewage sludge. Since liquid sewage sludge and septage are similar substances, the costs presented can be applied to septage land disposal. A 1976 report of Municipal Sludge Management by the EPA Construction Grants Program[3] reports that the total costs for land application (Construction Grants Files) including construction and operation costs to handle the sludge generated from 1 MGD plants is $127-168/dry ton of solids. Translated into dollars per 1000 gals of septage @ 5% solids, costs fall between $27-35. These costs seem very high and may be unreliable since no details of the land application are discussed. A Solid Waste Management Series report[4] reviewed 24 case studies of municipal sludge land disposal. The average cost for liquid sludge surface disposal was $32/dry ton of solids ($6.72/1000 gal of septage @ 5%). The range of costs was from a low of $5/ton dry solids ($1.05/1000 gal septage @ 5%) to $81/ton dry solids ($17/1000 gal septage @ 5%). Spray irrigation of sludge at MGD Chicago was $71/ton dry solids ($15/1000 gal septage @ 5%). The cost reported for MSD included cost for anaerobic digestion and barging to the site. Excluding these costs, the spray irrigation at Chicago amounted to $5/1000 gal of liquid sludge @ 5% solids.

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## SUBSURFACE DISPOSAL

### Description of Process

Subsurface application techniques have gained wide acceptance as alternatives for disposal of liquid sewage sludge and to some extent, septage. Such soil incorporation techniques provide some control of odors and vectors and reduce the potential for human contact. For this reason, these alternatives are generally more environmentally and aesthetically acceptable than surface application, although costs for subsurface disposal are higher.

Plow-Furrow-Cover (PFC), Subsoil Injection (SSI) and a Terreator™ have been investigated as septage disposal techniques by Kolega, et al. All were found to be effective means of incorporating septage into the soil mantle. No groundwater contamination was observed after a 12 week application of 120,000 gal. over a 5 acre plot in Connecticut using these three methods.

Three basic approaches to subsurface disposal are available:

1. Incorporation using a farm tractor and tank trailer with attached subsurface injection equipment

2. Incorporation using a single, commercially available tank truck with subsurface injection equipment, or

3. Incorporation using tractor-mounted subsurface injection equipment in conjunction with a central holding facility and flexible "umbilical cord"; liquid sludge is continually pumped from the holding tank to the disposal equipment.

Plow-Furrow-Cover (PFC) equipment uses a single mold-board plow, furrow wheel, and coulter. Septage is applied to the plowed furrow 6-8 in. below the original surface and is immediately covered by a following plow. In the Connecticut study, application rates were about 1 gal per linear foot (equivalent to 32,700 gal/acre).

Subsoil Injection (SSI) studies by Kolega provided for application of about 2 gal/linear foot (43,560 gal/acre). This device injects a wide band or several narrow bands of septage six to eight inches beneath the sod surface.

The Terreator™ is a patented device which utilizes an oscillating chisel point to form a 3 3/4 in. diameter mole-type hold. Septage is applied to a depth of twnety inches at a rate of about 2 gal/linear foot. Since application passes were spaced at five feet in the Connecticut study, the overall application rate was about 17,420 gal/acre.

Some states have published guidelines for septage application to the land. Maine limits the application rate based on N loading. This seems reasonable, as metal content is relatively low in septage. Thus, in any one year, maximum application rates are 62,500 gal/acre (500 lb. N/acre) for well drained soils and 37,000 gal/acre (300 lb. N/acre) for moderately well drained solids (from Maine Guidelines for Septic Tank Sludge Disposal on the Land).

Net nitrogen loadings to the soil will be generally higher for subsurface disposal than surface application, as $NH_3$ loss will be greatly reduced.

For any designated land disposal site, groundwater and soil monitoring should be conducted on a routine basis.

## Design Considerations

1. Climate-
   subsurface disposal not possible during wet and frozen ground conditions; investigate rainfall, temperature, evaporation data.

2. Equipment selection and sizing
   a. holding tanks
   b. injection equipment
   c. pumps, etc.

3. Rate and frequency of application-

   limiting rate should be based on nitrogen loading rather than metal loading.

4. Soil and groundwater monitoring

5. Winter holding or contingency plan-

   septage handling plan during months of frozen/wet ground conditions; may be large holding tank(s) or alternative disposal plan, such as a sewage treatment plant.

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Less potential for human contact | Large land requirements |
| Less odor, vectors | Monitoring required |
| Aesthetically acceptable | Contingency and/or holding for wet or frozen ground |
| Soil amendment, fertilizer value of waste | Somewhat greater equipment requirements than with surface spreading |

## Costs

Since no full scale data are available from operating subsurface disposal facilities for septage, only estimates of cost are available. However, such estimates are reasonably easy to develop from the wealth of information in the sewage sludge literature. In the estimates presented here, transportation costs incurred by the hauler to and from the disposal site have not been included. This generally accounts for a significant portion of sewage sludge disposal costs.

One consultant's study in Tompkins County, New York estimated the total annual cost for a central septage disposal facility to be $22/1000 gal (June, 1978 dollars). The additional cost to the hauler for increased transport distances would have been significant in this case. Providing three local holding facilities and a tank truck to transfer septage to the central disposal site increased the total annual cost to $35/1000 gal (June, 1978). The design capacity for these alternatives was 2.1 million gallons/year (equivalent to a non-sewered population of about 30,000). Other investigators have indicated considerably lower costs. Reasonable total annual costs for the design and construction of a subsurface disposal facility for septage are likely to be in the range of $20-$35/1000 gal. Economics of scale become important with land based systems.

### Bibliography

Kolega, I.J., Dewey, A.W., Cosenza, B.J., Leonard, R.L. "Treatment and Disposal of Wastes Pumped from Septic Tanks" USEPA Environmental Protection Technology Series, EPA-600/2-77-198, September 1977.

Carroll, T.F., Maase, D.L., Genco, J.M., and Ifeadi, C.N. "Review of Landspreading of Liquid Municipal Sludge," EPA Environmental Protection Technology Series, EPA-670/2-75-049, available only from NTIS - PB 245-271/AS, $5.25, June 1975.

Sommers, L.E., Fehrmann, R.C., Selznick, H.L., and Pound, C.E. "Principles and Design Criteria for Sewage Sludge Application on Land" in Sludge Treatment and Disposal, EPA Technology Transfer Seminar Handout, May 1978.

Houch, C.P., and Smith, J.L., "Subsurface Injection--How Much Does it Cost?" Water and Wastes Engineering, January 1977.

## TRENCH DISPOSAL

### Description of Process

Disposal of septage by placement and/or burial in excavated trenches is a common technique for handling septage in rural areas. However, in many cases, this method has been implemented by both private (hauler) and public (municipal) entities as a temporary solution, without careful consideration of environmental consequences and currently available engineering design practices. Although many trench configurations are possible, often they are 3-6 feet deep and 2-3 feet wide, with lengths varying with site location. Spaces between trenches is sufficient to allow movement of heavy equipment. A series of trenches is usually dug, allowing sequential loading to maximize the dewatering rate. Six to eight in. lifts of septage are applied to the trench. When the trench fills, two alternatives are possible: remove the solids (if sufficient dewatering has occurred) and dispose of them in a landfill, or cover the trench with two feet of soil. The first option may allow the trench to be reused. By enlarging the trench slightly, the infiltrative capacity may be restored. However, depending on soil conditions and climate, the solids removed from the trench may be of insufficient dryness for disposal at a sanitary landfill.

In some cases, the trenches are dug at sanitary landfill sites, adjacent to the fill area. Thus, if the partially dewatered solids are removed from the trench, they may be disposed of in the landfill in a similar fashion to sewage sludge.

The primary environmental consideration with trench disposal of septage is groundwater contamination. In most cases, disposal sites are chosen with soils that will allow the greatest infiltration rate. Unfortunately, these are often the same soils that provide the least renovative capacity. A minimum of four feet between seasonal high groundwater and trench bottom is recommended. A groundwater monitoring strategy should be included in any design, as the potential for groundwater contamination may often be high.

Sites for trench disposal of septage may have limited lifetimes due to 1) groundwater contamination or 2) exhaustion of available land at the site. Consideration should be given to adequate buffer areas as odors may be a problem.

1. Equipment - backhoe
2. Groundwater monitoring (bacteria, $NO_3$)
3. Estimated design life of site

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Simple | Potential groundwater contamination |
| Easily implemented | Odors, vectors |
| Relatively low cost | Limited design life |

## Costs

Barlow and Cassell have estimated the costs of trench disposal facilities for 100,000 and 250,000 gal/yr of septage for five and ten year site lives, with and without monitoring. These costs are summarized in Table 4. A typical breakdown of these costs is shown in Table 5. These figures are considered to be representative of a properly designed and operated septage disposal facility employing the trenching technique.

Economics of scale are evident in Table 4. Due to the short lifetime of the sites, annual costs are sensitive to the capital investments of land and site construction.

## Bibliography

Barlow, Gill and Cassell, E. Alan, "Technical Alternatives for Septage Treatment and Disposal in Vermont," Vermont Water Resources Research Center, University of Vermont, January 1978 (Draft)

Cooper, I.A., and Rezek, J.W., "Septage Management," USEPA Environmental Protection Technology Series, 1978 (Draft)

Walker, J.M., Burge, W.D., Chaney, R.L., Epstein, E., and Menzies, J.D., "Trench Incorporation of Sewage Sludge in Marginal Agricultural Land", USEPA Environmental Protection Technology Series, EPA-600/2-75-034, September 1975.

TABLE 4

Estimated Costs of Trench

Disposal Facilities for Septage (1977)

(Barlow, Cassell)

| Capacity, gal/yr | 100,000 | 100,000 | 250,000 | 250,000 |
|---|---|---|---|---|
| Site life, yr | 5 | 10 | 5 | 10 |
| Land req'd, acres | 15 | 19 | 20 | 27 |
| Total annual cost, $ | | | | |
| w/monitoring | 6499 | 5279 | 8618 | 7195 |
| w/o monitoring | 5150 | 4023 | 7249 | 5939 |
| Cost/1000 gal, $ | | | | |
| w/monitoring | 65 | 53 | 34 | 29 |
| w/o monitoring | 52 | 40 | 29 | 24 |

## TABLE 5

### Disposal Trench Cost Estimate --
### 250,000 Gallon/Year Capacity, 10 Year Site Life (1977)
(Barlow, Cassell)

| | with monitoring $ | w/out monitoring $ |
|---|---|---|
| CAPITAL COSTS | | |
| Fencing | 4900 | 4900 |
| Access Road | 3500 | 3500 |
| Initial Site Preparation | -- | -- |
| Monitoring Wells | 1000 | 1000 |
| Contingencies (@10%) | 940 | 840 |
| Engineering (Site Investigation) | 1200 | 1200 |
| Total Capital Cost | 11540 | 10440 |
| Annual Amortization (7%/10 yrs) | 1643 | 1487 |
| LAND COSTS | | |
| Annual Amortization 27 ac @ $500/ac = $13500 @ (7%/10 yrs) | 1922 | 1922 |
| or | | |
| Annual Rental | | |
| OPERATING COSTS | | |
| Labor | -- | -- |
| Excavation, Final Cover and Grading | 2000 | 2000 |
| Lime | -- | -- |
| Snowplowing and Road Maintenance | 200 | 200 |
| Lab Analysis | 1000 | 1000 |
| Record Keeping | 100 | 100 |
| Contingencies (@10%) | 330 | 230 |
| Total Operating Cost | 3630 | 2530 |
| TOTAL ANNUAL COST | 7195 | 5939 |
| $/1000 GALLONS OF SEPTAGE | 29 | 24 |

## SANITARY LANDFILL DISPOSAL

### Description of Disposal Practice

Sanitary landfills in the U.S. generally accept a multiplicity of materials such as solids wastes, semi-solids, and hazardous wastes. All of these wastes are compiled on a daily basis at the landfill and buried under a soil covering by various methods to control run-off, leachate, odors, and rodent infestation. The practice of landfilling municipal sewage sludge has occurred extensively throughout the U.S. but the material is usually required to be dewatered to a solid consistency in order to minimize free water drainage and leaching. The acceptance of septage at a landfill would depend chiefly on the ratio of the mixture of liquid waste (septage) to solid waste so that a certain degree of total moisture content can be achieved prior to burial. Only a few states have laws completely restricting the disposal of septage into a landfill and others do not recommend landfill disposal because moisture control is too difficult to maintain. However, septage is disposed of in sanitary landfills with and without moisture control.

### Design Parameters

Although most states do not have specific design criteria for septage disposal in a landfill all states do have criteria for location, design, and operation of solid waste disposal landfills. Some standard operational criteria are:

1. Depth of burial and a minimum soil cover over the waste at the end of each day are critical to the standard operation of all sanitary landfills(1).

2. With specific regard to septage, New Jersey requires a maximum of ten gallons of septage/cubic yard of solid waste in order to maintain the moisture content at a low level. The California regulations are 25 - 40 gallons/cubic yard of solid waste.

3. It is recommended by the NEIWPCC(2) that facilities for the collection and treatment of leachate should be provided. If these facilities exist then the limitations for loading septage into the disposal site can be determined and adjusted depending on the facilities for collecting and treating the leachate.

4. Other devices such as groundwater monitoring wells should be used on a regular basis to determine any change in groundwater quality possibly due to septage loading.

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Simple operation | Limited application in high rainfall areas due to runoff conditions |
| No topographical limits | Possible odors generated during trenching or cell filling |
| Pathogen problems minimized by soil cover | Good control of liquid-solid mixing essential |
| Generally a low cost disposal method | Extensive monitoring of leachate, runoff, and groundwater |

## Costs of Sanitary Landfilling

Sanitary landfilling costs for septage are not readily available especially if the septage is accepted at a functioning landfill with no previous cost base. Various sources for data on costs are available for municipal sludge cake disposal at landfills. However, costs are usually reported on a wet ton basis since sludge cake (20% solids and 80% moisture) is generally accepted at the disposal site while liquid sludge is not. A report by SCS Engineers on sludge landfilling was included in the May 1978 EPA Sludge Treatment and Disposal Seminar Handout(3). An average value of $24/dry ton of sludge solids was computed for a total of 16 different landfill sites. On a liquid basis for septage this cost would be $5/1000 gallons septage @ 5% solids. The range of actual values found for the 16 sites is:

| | | |
|---|---|---|
| 44% of sites | < | $2.10/1000 gal. septage @ 5% solids |
| 25% of sites | < | $4.20/1000 gal. septage @ 5% solids |
| 19% of sites | < | $6.30/1000 gal. septage @ 5% solids |
| 12% of sites | > | $6.30/1000 gal. septage @ 5% solids |

The major cost variable, although not reflected in the costs shown above, would be the labor required to manipulate the mixture of septage and solid waste. As with all land disposal alternatives the land cost also enters in the analysis.

## References

1. "Sanitary Landfill Design and Operations," U.S. EPA, 1972, SW-65ts.

2. "Guidelines for Septage Handling and Disposal," New England Interstate Water Pollution Control Commission, TGM-1, August, 1976.

3. "Sludge Treatment and Disposal," Part II, U.S. EPA Technology Transfer Seminar Handout, May 1978.

# INDEPENDENT SEPTAGE TREATMENT FACILITIES

## LAGOON DISPOSAL

### Description of Process

The use of lagoons for disposal of septage is a common alternative for rural towns. The design and operation of lagoons varies widely from simple seepage pits to underdrained basins with separate percolation beds. Most lagoons are operated in an unheated anaerobic or facultative phase. Aerated lagoons are also operated for septage treatment and disposal, generally requiring considerably more maintenance than the non-aerated type. Septage is usually placed in the lagoon via a vertical discharge chamber entering under the surface of the liquid near the lagoon bottom to minimize odors although resuspension of solids by this technique has been reported. As the septage solids anaerobically digest, the liquid portion passes through the bottom sand and soil for purification. Once the lagoon is full, the liquid is allowed to percolate and evaporate until the solids are dry enough for removal. Some lagoons are operated with an overflow outlet which can periodically remove supernatant to an infiltration/percolation bed for further treatment. The pH of a lagoon must be periodically adjusted to 7-8 to control odors. An aerated lagoon treatment system for septage is operated similarly to an aerated lagoon system for treating wastewater. However, septage is a very strong waste and can upset an aerobic system if shock loads are frequent.

### Design Parameters

1. Design criteria for lagoons are mainly centered around site location, which will insure proper protection of water supply wells, surface water, groundwater, and inhabited dwellings.

2. A geologic, hydrologic, topographic, and climatic study is critical and should be made of the proposed site prior to construction.

3. Unless the state has other regulations on design criteria the lagoon should be a minimum of three feet deep, the bottom should be at least four feet above the water table, and the lagoon should be constructed so that one third of its volume is located above ground level to maximize the hydraulic gradient and evaporation.

4. The lagoon should be maintained at pH 6-8 with hydrated lime by adding the lime each time a pumper discharges into the receiving chamber.

5. Floating scum should be removed or sunk by dusting dry hydrated lime over the surface of the lagoon.

6. A clear surface should be maintained at all times.

7. A routine monitoring program should be established to monitor influent, sludge depth, and pH.

8. Ground water should also be monitored near the lagoon site. Design criteria are listed in detail in the "Guidelines for Septage Handling and Disposal"(1).

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Low cost (capital, operation maintenance) | Occasional odor problems if pH not maintained |
| Septage discharge can be regulated easily by fence, gate, and volume log book | Site location restricted by high water table |
| | Possible vector problem |
| Not affected greatly by climate | Possible soil clogging which may stop percolation |
| | Final solids disposal may be required |

## Costs

No actual costs for septage disposal in lagoons are available. However, several engineering studies have produced cost evaluation of septage disposal in lagoons at specific locations. These costs range from \$5 to \$20/1000 gallons of septage. The greatest cost determining factors are land cost, and solids disposal costs. Monitoring may also be a large factor for operational cost depending on local requirements for groundwater monitoring.

## References

1. "Guidelines for Septage Handling and Disposal," New England Interstate Water Pollution Control Commission, TGM-1, August 1976.

## LIME STABILIZATION

### Description of Process

Stabilization of septage by the addition of lime to pH 12 is an effective treatment method. This process can be used as an independent process or as a process for septage received at a sewage treatment plant. The stabilization process consists of septage collection, mixing and reaction with lime to pH 12. The stabilization may be followed by a dewatering step or the stabilized liquid septage may be spread on the land. Once the septage is stabilized at pH 12, it is low in pathogens, the putresible odors are eliminated, and the organics not easily decomposed. Data from a research demonstration at Lebanon, Ohio shows the effect of lime addition to pH 12 on the septage brought to the sewage treatment plant for disposal. Table 6 shows the pathogen count for various indicator organisms before liming and after. It should be pointed out that lime stabilization is a treatment process and not a final disposal alternative. Once the septage has reacted with lime the stabilized product must be either dewatered and the solids disposed of in an acceptable manner, or the stabilized product in liquid form may be applied to the soil for disposal. Deodorization is achieved and maintained by this process.

Table 6

Indicator Organism and Pathogen Destruction
By Lime Stabilization of Septage

| | Septage (as received) organisms/100 mℓ | Septage (limed pH 12) organisms/100 mℓ |
|---|---|---|
| Salmonella | 6 | <3 |
| Ps. aeruginosa | 754 | <3* |
| Fecal coliform | $1.5 \times 10^7$ | $2.6 \times 10^2$ |
| Total coliform | $2.8 \times 10^8$ | $2.1 \times 10^3$ |
| Fecal streptococci | $6.7 \times 10^5$ | $6.6 \times 10^2$ |

*detectable limit = 3

## Design Criteria

1. For an independent system the lime stabilization process would require a receiving station and a tank to store a 2-day volume of waste.

2. The septage could then be mixed mechanically or by air while a lime slurry (25%) is pumped into the tank.

3. The pH should be monitored throughout the slurry addition until pH 12 is reached. Stabilization is normally complete when pH 12 is maintained for at least one hour without further addition of lime.

4. The quantity of lime required for stabilization is variable depending on the alkalinity and solids concentration of the septage. A range of lime quantity required for pH 12 stabilization is 0.1 to 0.3 lb lime/lb dry solids. In terms of 1000 gallons of septage at 5% solids this range is 42 to 125 lb lime/1000 gal. septage. Design parameters for this system consist of estimating daily volume of septage for sizing tanks and lime demand, mixing methods (air or mechanical), pH monitoring, and final disposal of lime stabilized septage.

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Deodorization achieved | No organic reduction |
| Good pathogen reduction | Lime addition increases disposal quantity |
| Simple chemical process with pH control | Fate of long term storage unknown |
| Dewaters better on sand drying beds | Cost for labor and lime high |

## Costs

Costs for lime stabilization of septage have been demonstrated in two research projects by EPA(1, 2). Both demonstrations and cost figures include final disposal of septage solids. The cost evaluation by Feige, et. al.(1), involved lime stabilization at a sewage treatment plant and sand drying (covered) bed dewatering. The total cost was $30/1000 gallons septage at 4% solids. Another study on lime stabilization was done at the same sewage plant by Burgess & Niple Ltd.(2). Although this study was primarily used for demonstrating lime stabilization of municipal sewage sludge, septage was also lime stabilized and disposed by surface spreading on farm land just as the municipal sludge. The total cost for lime stabilization and land spreading was $13/1000 gallons septage at 4% solids. A cost estimate for lime stabilization of septage in an independent facility was made by Brown and White(3). Their cost estimate was based on a design for lime stabilizing septage and providing a storage basin to hold six months of septage in case of frozen or wet land. The total figure was $17.80/1000 gal. septage (1 million gal. per year collection) to $12.10/1000 gal. septage (2.5 million gal. per year collection).

## References

1. Feige, W.A., Oppelt, E.T., Kreissl, J.F., "An Alternative Septage Treatment Method: Lime Stabilization/Sand-Bed Dewatering," U.S.EPA Environmental Protection Technology Series, EPA-600/2-75-036, Sept. 1975.

2. Noland, R.F., Edwards, J.D., Kipp, M., "Full Scale Demonstration of Lime Stabilization," EPA Environmental Protection Technology Series, draft, 1978.

3. Brown, D.V. and White, R.K., "Septage Disposal Alternatives for Rural Areas," Ohio Ag. Res. and Dev. Center & OSU Cooperative Extension Service, Research Bulletin 1096, Extension Bulletin 624, Dec. 1977.

## CHLORINE OXIDATION

### Description of Process

A number of installations exist across the country that utilize the BIF-Purifax™ process for stabilization of sewage sludge and/or septage. This process introduces chlorine gas along with sludge into a pressurized (30 - 40 psi) reaction chamber. The manufacturer describes the process as one in which "chlorine gas reacting with water at pH 1.5 to 2.5 produces hypochlorous acid and nascent oxygen which oxidizes the sludge."

Chlorine dosages vary from 700 - 3000 mg/ℓ, depending upon the solids content of the slurry and the amount of chlorine-demanding substances present (ammonia, amino acids, proteins, carbonaceous material, and hydrogen sulfide).

When properly operated, the system is capable of producing a stabilized, straw-colored sludge that is free from objectionable odors and which will readily dewater on sand drying beds. Studies at the EPA-Lebanon, Ohio pilot plant showed that the chlorine-oxidized sludge dewatered on sand drying beds to at least 32% total solids in three days. The material had a slight medicinal odor when it first emerged from the reactor. The process was found to be effective in reducing total and fecal coliform counts (see Table 7). Relatively high levels were observed in the underdrainage, although the dried sludge cake was not analyzed for bacteriological regrowth. Further treatment of the underdrainage liquor would be required for surface discharge.

Table 7

Purifax™ Treatment of Septage
Bacteriological Data
- Values are Averages of Four Runs -

| | Total Coliform (counts/100 ml) | Fecal Coliform (counts/100 ml) |
|---|---|---|
| Raw Septage | $4.4 \times 10^7$ | $5.3 \times 10^6$ |
| Purifax Treated Septage | <200 | <200 |
| Average Sand Bed Underdrainage | $6.9 \times 10^6$ | $3.2 \times 10^4$ |

The pH of the chlorinated slurry is generally reduced to between 1.5 and 2.5. If the slurry is to be dewatered by mechanical means, consideration should be given to pH adjustment with lime or caustic.

At least one installation discharged the stabilized septage into a holding lagoon. However, this resulted in a significant odor problem when further decomposition was allowed to occur under anaerobic conditions.

Recently, questions have been raised as to the environmental acceptability of chlorine-stabilized sludges. A laboratory study by EPA has indicated high percentages (1% by weight) or organic chlorine in the solid phase of superchlorinated septage. It was suggested that this could represent a significant potential environmental hazard. Unfortunately, analytical techniques for identification of specific substances produced by superchlorination of septage are not well developed at this time. In addition, the relative toxicity of such compounds is often unknown or difficult to quantify. However, despite the difficulty in assessing the toxicity of these materials, consideration must be given to ensuring environmentally sound, agency-approved, techniques for disposal of the residuals from this process.

### Design Considerations

1. Equipment sizing and selection - through BIF - Purifax, Inc.
2. Dewatering - selection of process; if mechanical, neutralization may be required; consideration of treatmentdisposal of liquid fraction from dewatering operation.
3. Cake disposal - selection of disposal site; environmental assessment.
4. Chlorine storage/safety.

### Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Produces stable, odor-free sludge | Relatively high operating costs |
| Easily dewatered | Operating cost dependent on $Cl_2$ price |
| High pathogen destruction | Neutralization may be required |

| | |
|---|---|
| Relatively simple operation | Question of harmful chlorinated organics |
| | Acceptable cake disposal required |

## Costs

Capital and annual costs for treatment of septage by the Purifax process will vary as a function of 1) size of facility, 2) type of dewatering technique selected (which may also affect the requirement for neutralization), cost of chlorine, method of cake disposal, and need for leachate treatment/disposal.

The Purifax process appears to be cost competitive with other mechanical processes used for independent septage treatment facilities (e.g., physical/chemical systems). One of the economic disadvantages is the high chlorine requirement and thus the dependency of operating costs on chlorine price. During the past five years, fluctuation in the price of chlorine has been considerable.

Estimates of the total amortized cost for Purifax treatment of septage range from \$30 - \$60 per 1000 gal. Obviously, the actual cost may vary considerably, dependent on the factors listed above.

## Bibliography

Anon., "Septic Tank Sludge Treatment by the Purifax Process of Rapid Chemical Oxidation," BIF, A Unit of General Signal, 1600 Division Road, W. Warwick, RI 02893.

Bender, Jon H., "Evaluation of the Purifax Process for the Treatment of Septic Tank Sludges," U.S. EPA Lebanon Pilot Plant, draft report, June 1975.

Wise, R.H., Pressley, T.A., Austern, B.M., "Partial Characterization of Chlorinated Organics in Superchlorinated Septages and Mixed Sludges," U.S. EPA Environmental Protection Technology Series; EPA-600/2-78-020, March 1978.

## COMPOSTING OF SEPTAGE

### Description of Process

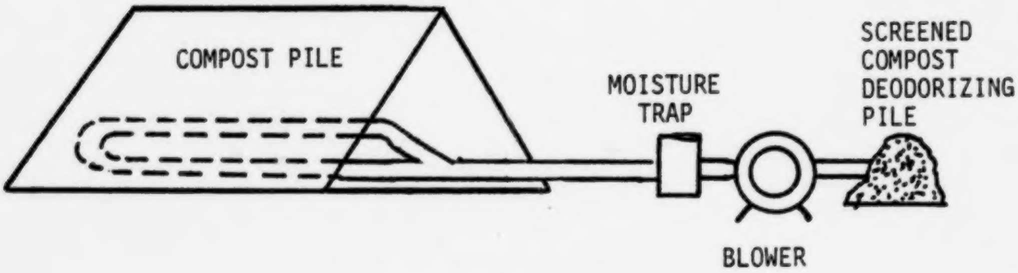
Composting is a process which has been employed for centuries for stabilizing a variety of organic wastes, and can be implemented as a septage treatment technique.

There are only a few septage composting facilities currently operating in the U.S. These are located in Washington, where septage is aerated (by the patented Lebo process) and sprayed onto bermed piles of sawdust. Alternating layers of septage and sawdust are applied. Although the process appears to be effective, little data is available. Since the piles are not mixed, it may be questionable as to whether uniform distribution of adequately high temperatures ( 60$^{o}$) is consistently achieved. This is essential to provide complete pathogen destruction.

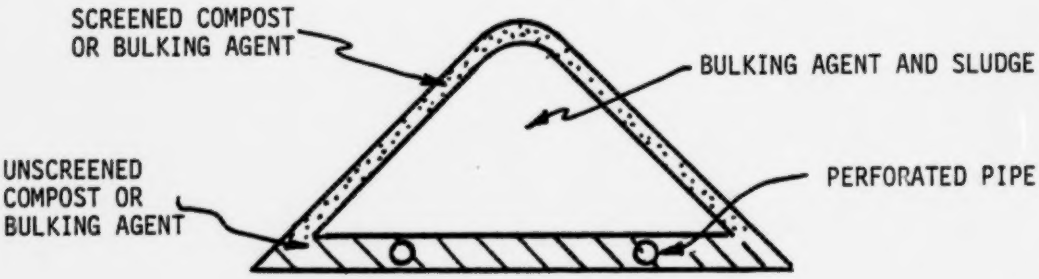
One composting technique which appears to offer potential as a septage treatment alternative is the Beltsville "static pile method." Septage composting by this technique has only been performed at the pilot level. However, the National Park Service has been using this approach for two years for composting liquid wastes pumped from portable toilets.

The essential elements of the static pile method are shown in Figure 2. An aeration header consisting of perforated pipe is placed on the ground and covered with approximately 30 cm (12 in) of wood chips or unscreened, previously composted material. A front end loader or some mixing device is used to blend the bulking agent (sawdust, wood chips, or other material) and raw sludge in the appropriate proportion. The mixture is then placed on the base. The pile is covered with a 30 cm (12 in) layer of screened compost to provide insulation (minimizing loss of generated heat) and to prevent odors from escaping. Vacuum is applied to the header by the use of a blower. Between the pile and blower, a moisture trap is generally installed to collect water which condenses in the piping. The discharge from the blower is operated on a timer, allowing an operator to adjust the cycle to maintain oxygen concentrations in the pile of between 5 and 15 percent. A three week composting period is usually provided, during which time temperatures and oxygen levels in the pile are monitored. The composted material is then moved to a stockpile for a four week or more curing period. Screening of the material to recover the wood chips may be effected before or after curing. The compost is then ready for distribution.

If composting liquid septage is contemplated, the bulking agent (particularly sawdust) requirement may be substantial to provide adequate absorption of the liquid. Pilot studies indicate a bulking agent requirement of up to 20 cubic yards per 1000 gal septage. This could be reduced considerably by employing a septage dewatering step prior to composting or dried compost recycling.


COMPOST PILE
MOISTURE TRAP
SCREENED COMPOST DEODORIZING PILE
BLOWER

GENERAL LAYOUT


SCREENED COMPOST OR BULKING AGENT
BULKING AGENT AND SLUDGE
UNSCREENED COMPOST OR BULKING AGENT
PERFORATED PIPE

CROSS SECTION

FIGURE 2: SCHEMATIC OF FORCED AERATION STATIC PILE COMPOSTING SYSTEM

## Design Parameters

1. Bulking agent cost and availability - Consideration of long term availability and cost of bulking materials. Bulking agents would represent a substantial portion of the annual operational costs.

2. Facilities design -

Materials handling - Mixing of pile constituents may be manual (front-end loader) or mechanical (pug mill, others). Similarly, transport may be via front end loader or conveyor belt, etc. Potential human/waste contact should be minimized.

Aeration system - This should include 4 - 6" perforated pipe, moisture trap, 1/2-hp blower, small compost pile for odor removal, and ancillary piping.

Leachate production - Consideration should be given to leachate generation, collection, treatment, and disposal, particularly if liquid sludge is to be composted.

3. Operational parameters

Moisture content - Approximately 50% moisture is desirable in septage/bulking agent mixture. Structural strength and porosity should be maintained.

C:N ratio - Carbon to nitrogen ratio will determine rate of composting, provided that adequate moisture content is maintained. This may be difficult to measure as composting rate is actually dependent on ratios of "available" nutrients. C:N ratios of 20-30 have been suggested as ideal.

Oxygen levels - Piles should be monitored for oxygen level. Air flow should be adequate to maintain oxygen levels of between 5 and 15% in the pile.

Temperature - Piles should be monitored for temperature at numerous points. Pathogen destruction is essentially complete if 60°C temperatures are maintained for several days. This is the most direct indicator of an effective composting process.

4. Compost market - A market must be available to handle large volumes of compost. Commerical and municipal markets (nurseries, landscaping companies, golf courses, parks) should be investigated. Potential revenue from sale of compost should be considered in the cost-effective analysis.

## Advantages/Disadvantages

ADVANTAGES

Provides high degree of stabilization and pathogen destruction

Capable of producing a marketable soil amendment

Operationally simple

Low energy requirements

Generally not affected by weather

Low capital cost for less mechanized operations

Achieves resource recovery

DISADVANTAGES

May have large bulking agent requirement (if composting liquid sludge) and thus high operational cost

Must establish product market or designated distribution points

Must ensure long term supply of bulking material

Leachate collection/disposal, if required, may add to cost and complexity of operation

Labor requirements may be high if materials handling is not mechanized

## Costs

Unfortunately, little cost data is available for composting of septage. Table 8 presents cost information from two sources: Western Minerals (Lebo) and Pio Lombardo (static pile). All figures are estimates generated from design studies. If sale of the compost product is not included, the total amortized cost for septage composting probably varies from $20 to $40 per 1000 gal. depending on process type, design flow, and actual design choice (e.g., degree of mechanization, presence of absence of dewatering step, etc.)

Experience with composting of dewatered sewage sludge has indicated the operation to be labor-intensive. Estimates for a 10 dry ton per day sludge composting facility show labor as being 43% of the total annual cost

Table 8

Estimated Costs of Septage Composting

| Process/Location | Design Flow gpd | Annual Cost, $/1000 gal. Capital | O&M | Total | Year | Reference |
|---|---|---|---|---|---|---|
| Lebo; Washington | 7500 | 5.70 | 21.82 | 27.52 | 1975 | Western Minerals |
| Lebo; Washington | 25,000 | 1.43 | 6.03 | 7.45* | 1976 | Western Minerals |
| Lombardo; static pile; Rehoboth, Mass. | 15,000 | 6.04 | 33.16 | 39.20 | 1977 | Pio Lombardo |
| Lombardo; static pile; Rehoboth, Mass. | 15,000 | 6.04 | 5.82 | 11.86** | 1977 | Pio Lombardo |

* Assumes revenue from final product ≈ $2.10 per cu. yd.
** Assumes revenue from final proudct ≈ $5.00 per cu. yd.

and 52% of the annual operating cost. Woodchips at \$3.50/yd$^3$ accounted for 24% of the annual operating cost. For composting of septage, sawdust would be required as a liquid absorbent. Lombardo assumed a sawdust cost of \$4.25/yd$^3$.

In a liquid septage composting operation, sawdust, unlike woodchips, could not be reused and thus could represent a significant portion of the annual operating costs. If the septage were to be dewatered to 20 - 25% solids, little sawdust would be required, and the woodchips could be reused up to four times. Dewatering may also reduce labor costs due to less overall materials handling requirements. An economic analysis should consider both options in light of bulking agent availability and cost.

Process design can have a major effect on the distribution of total costs between capital and operating expenditures. It is possible to employ a high degree of mechanization (particularly for materials handling) which will lower operating costs significantly. The analysis performed on the Beltsville research concluded that the cost per dry ton sludge was sensitive to changes in operating costs, but insensitive to equipment, land, and site development costs.

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Epstein, E., Willson, G.B., Burge, W.D., Mullen, D.C., and Enkiri, N.D., "A Forced Aeration Syetem for Composting Wastewater Sludge," JWPCF Vol. 48, No. 4, April 1976.

Colacicco, D., Epstein, E., Willson, G.B., Parr, J.F., Christensen, L.A., "Costs of Sludge Composting," Agricultural Research Service, USDA, ARS-NE-79, February 1977.

## AEROBIC DIGESTION

### Description of Process

The aerobic digestion process is a conventional sewage sludge treatment process to convert organic matter into $CO_2$ and water. For digestion of septage alone, the process has not been adopted at full scale. Several experimental batch systems have reported results of aerobic digestion of septage(1,2) but data on full-scale aerobic digestion of septage is available only for a combination of septage wtih sewage sludge(3). Solids Retention Times (SRT) for aerobic digestion of septage alone (batch experiments) are on the order of 20 - 40 days for good VSS reduction (40-50%) and solids separation. For septage-sewage sludge mixtures, the SRT appear to be nearer to 10 - 20 days to achieve similar VSS reductions. The septage of septage-sludge mixture is simply pumped into an acclimated aeorbic digester at a predetermined rate (detention time) and allowed to decompose aerobically. More frequent solids wasting may be required.

This process is a treatment (BOD and solids reduction) method requiring final disposal of the solids, possibly involving dewatering or direct land application.

### Design Considerations

1. The volume of septage to be digested is a critical factor in designing a new system or in modifying an existing reactor to accommodate sewage sludge and septage.

2. Organic loading should be in the range of 0.1 to 1.3 lb. VSS/ft$^3$/day.

3. Solids retention time as previously discussed is an important design parameter and should be from 10 to 30 days. The retention time will determine the extent of treatment (digestion). The annual temperatures lower than 20°C require longer SRT's for good VSS reduction.

4. An aerobic digester must function with a positive dissolved oxygen level. The aeration requirements theoretically needed can be calculated from the total organic loading to the digester(4).

### Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Reduction of suspended solids | Requires consistent operation |

| | |
|---|---|
| Reduction of BOD | Can be sensitive to toxic substances in septage |
| Reduction of odor and pathogens | Can be easily overloaded |
| May improve dewatering characteristics | Requires monitoring and lab analyses |
| | Product must be transported for final disposal |
| | Can be significant foam problem |

## Costs

Factors which affect the cost of aerobic digestion of septage are: air requirements, tank size, foaming controls, and final disposal. Other requirements depend on whether the operation takes place at a sewage plant having facilities for aerobic digestion or a plant constructed specifically for septage digestion. Costs involving aerobic digestion of sewage sludge only are about $4/1000 gallons. The Bend, Oregon plant aerobically digesting septage, vault toilet wastes, and sludge reports $14/1000 gallons.

## References

1. Jewell, W.J., Howley, J.B., Perrin, D..R, "Design Guidelines for Septic Tank Sludge Treatment and Disposal," Progress in Water Technology, 7, 2 (1975).

2. Howley, J.B., "Biological Treatment of Septic Tank Sludge," M-S Thesis, University of Vermont, October 1973.

3. C&G Engineers, "The Feasibility of Accepting Privy Vault Wastes at the Bend Waste Treatment Plant," prepared for the City of Bend, Oregon; Salem, Oregon, (June 1973).

4. "Aerobic Digestion of Municipal Wastewater Sludges," N.A. Mignone, Envirex Inc. EPA Seminar Handout - "Sludge Treatment and Disposal," March 1978.

## CHEMICAL TREATMENT OF SEPTAGE

### Description of Process

The addition of chemicals to treat septage can involve two different types of processes: (1) coagulation with alum, ferric chloride, or lime to cause a solid-liquid phase separation(1) (Figure 3 shows a general schematic of this process), and (2) a two-stage chemical process involving acidification of septage allowing solid-liquid separation, followed by second stage lime treatment of the liquid (supernatant) portion. The acidic and alkaline sludge portions generally can be dewatered or disposed of by conventional sludge handling techniques. Figure 4 shows the two stage system. Several alternatives exist for handling the alkaline liquid from the two-stage acid-lime process. These are: (1) containment/evaporation, (2) treatment to meet secondary standards for surface discharge, or (3) treatment and land application.

The chemical process alternatives mentioned above can be designed for independent septage processing plants with complete facilities for receiving, holding, chemical treatment, and final disposal of the solids and liquid. For most small towns a system of this type could be operated on a batch basis and would require only part-time operation. For large installations operated on a continuous basis, a full time operator would be employed.

### Design Considerations

1. Chemical feeding equipment must be sized for maximum chemical demand. Chemical dose levels must be determined by jar tests or some parameter such as pH or alkalinity.

2. Mixing, reaction time, and settling times are determined by jar testing prior to design.

3. Chemical addition to septage is a treatment method. The final disposal of liquid and solids must be considered when designing the entire system. Sludge dewatering or land disposal of liquid sludge can be a significant part of the design and are discussed in other sections. For surface discharge of the liquid fraction, further treatment would be required to meet secondary discharge standards.

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Chemical process requiring routine operation | Requires considerable labor |
| Control problems minimized | Final disposal of solids and liquid required |
| Minimal land required | High capital, operating, and maintenance costs |

## Costs

Only two installations for chemical treatment of septage have been constructed and operated. Both operations used chemical precipitation and vacuum filtration of the sludge. Dependable cost figures for the processes were not obtained. Several cost estimates have been made for chemical treatment plants, all of which appear to be greater than \$30/100 gal. septage. The E.C. Jordan Co. completed an EPA pilot study on chemical treatment of septage(2) and found a cost range for several chemical treatment alternatives of \$14 - \$37/1000 gal. septage.

## References

1. Cosulich, W.F., "Stop Dumping Cesspool Wastes," The American City, Vol. 83, February, 1968, pp 78-79.

2. Condren, A.J., "Pilot Scale Evaluations of Septage Treatment Alternatives," Environmental Protection Technology Series, draft, 1978.

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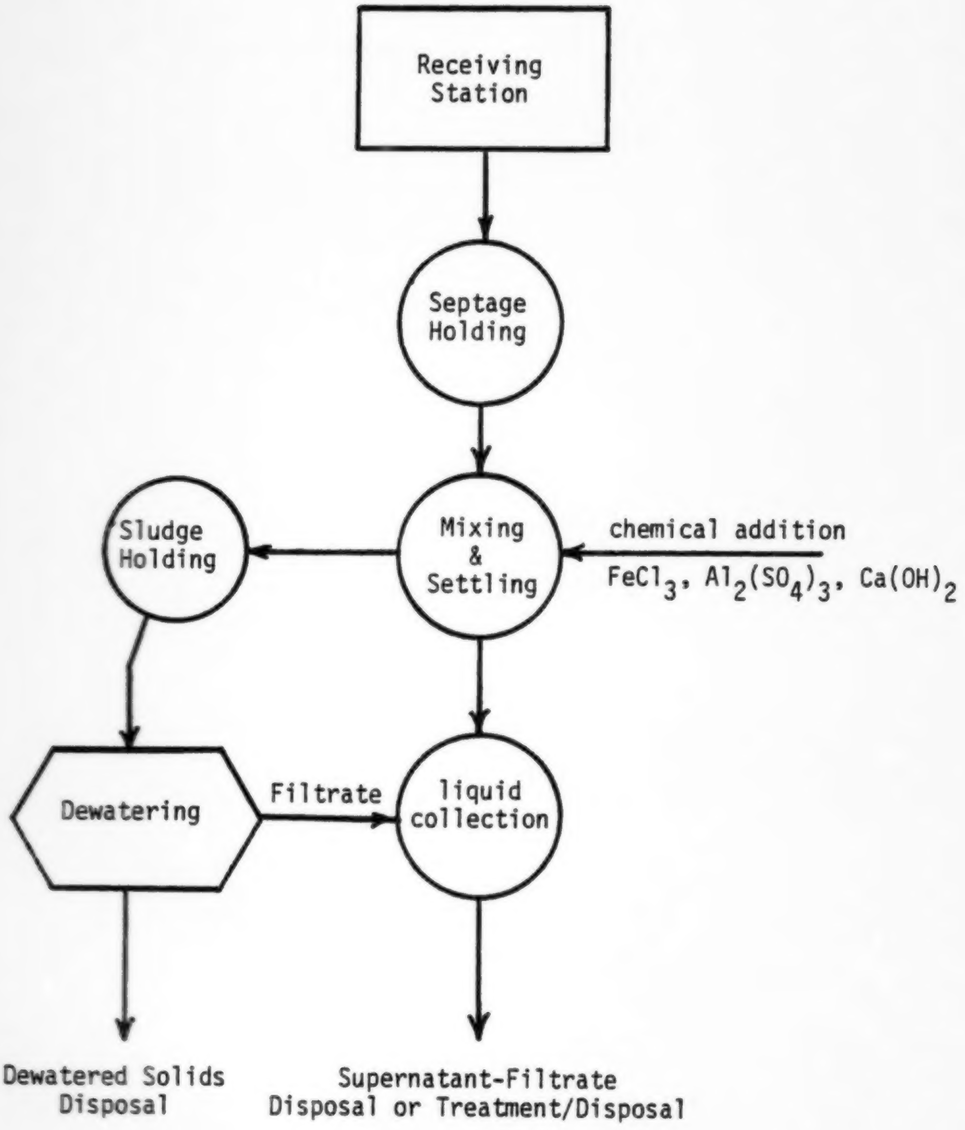
Receiving Station
Septage Holding
Mixing & Settling
chemical addition
$FeCl_3$, $Al_2(SO_4)_3$, $Ca(OH)_2$
Sludge Holding
Dewatering
Filtrate
liquid collection
Dewatered Solids Disposal
Supernatant-Filtrate Disposal or Treatment/Disposal

Figure 3 Schematic of Chemical Coagulation Process

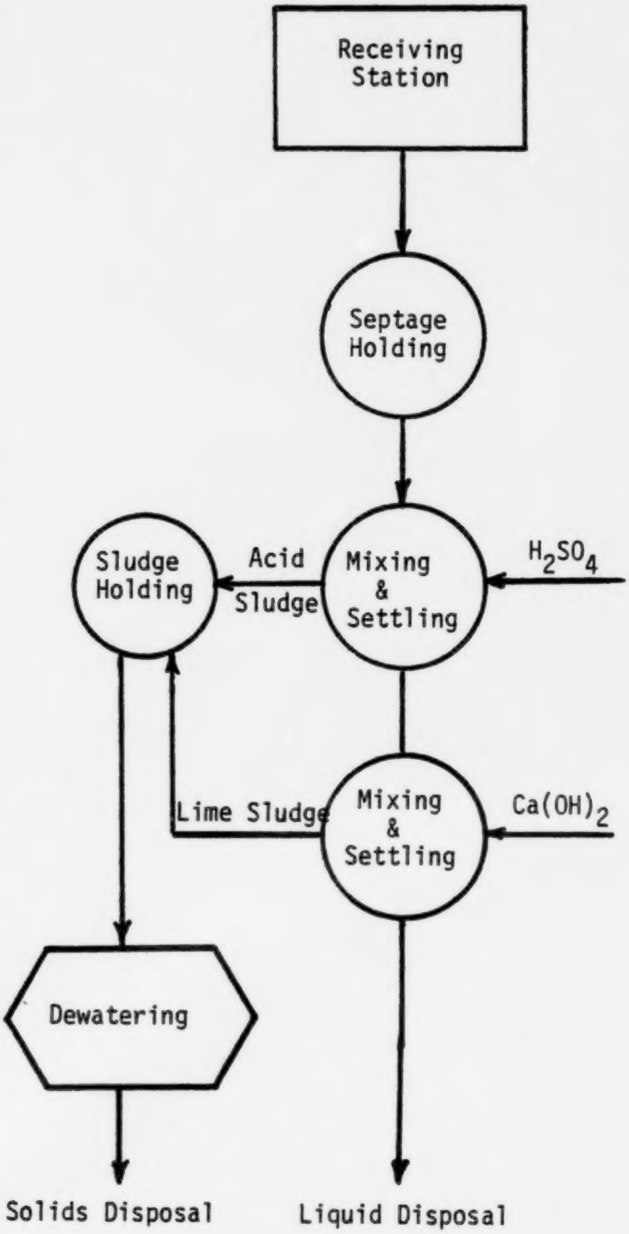
Receiving Station
Septage Holding
Sludge Holding
Acid Sludge
Mixing & Settling
$H_2SO_4$
Lime Sludge
Mixing & Settling
$Ca(OH)_2$
Dewatering
Solids Disposal
Liquid Disposal

Figure 4 Schematic of Acid-Lime Process

## DEWATERING

### Description of Process

Dewatering is mentioned in this section only to point out the various options available. Few dewatering devices have actually been used for septage dewatering. Except for sand drying beds and vacuum filters, other dewatering devices have not even been considered as an option. However, this step is a vital one in all septage treatment systems requiring final solids disposal. The land disposal category includes sanitary landfill acceptance of septage. In many states, liquid septage is not allowed in the landfill site. The septage is required to be dewatered prior to disposal. An independent septage treatment plant may be designed to treat the waste by any of the options previously mentioned.

Residuals generated from the following alternatives may require some type of dewatering prior to disposal:

lime stabilization
pressure chlorination
chemical treatment
aerobic or anaerobic digestion
composting (dewatering may be advantageous prior
    to composting)

If the septage is accepted at a sewage treatment plant for treatment and disposal in the liquid or sludge stream, some dewatering method is usually employed at the treatment plant, unless land application of liquid sludge is employed. The principal dewatering processes used for municipal sewage sludge applicable to septage are:

drying beds
pressure filtration
vacuum filtration
drying lagoons
centrifugation

Sand drying beds and drying lagoons are by far the most widely used dewatering methods and are the lowest cost items in terms of capital costs. Sewage plants that are currently accepting septage may also have vacuum filters to process sludge. Centrifugation and pressure filtration of septage in the U.S. have only been studied in pilot tests(1). Use of a centrifuge at a sewage treatment plant in Norway(2) has proven very effective for dewatering the septage. It was found that the use of a grinder before the centrifuge cuts down on the labor required for cleaning. Polymers are used to condition the sludge-septage mixture.

## Design Considerations

1. The volume of septage is quite critical to the sizing of the units.
2. Suspended solids concentration will affect the sizing and the final disposal method.
3. Filterability is a very important design factor affecting rate of cake production, labor requirements, cake moisture, and sizing of the units.
4. Chemical conditioning of the septage is required for pressure filtration, vacuum filtration and centrifugation dewatering processes and will affect dewatering rate, moisture content, and mass to be disposed.
5. Final disposal must be decided before the dewatering is selected.

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Produces a filter cake with low free water | High cost can be significant portion of total treatment costs |
| Reduces hauling costs to disposal site | Operation and maintenance requirements high |
| May be required for certain types of disposal | Mechanical dewatering systems require building a covered enclosure |

## Costs

Although considered separately here, dewatering would always be merely a part of an overall septage treatment and disposal scheme. In only a few locations has septage conditioning/dewatering been attempted on a full scale. In many of these instances it has been in combination with sewage treatment plant sludge.

Condren has estimated total annual costs for an independent septage handling facility (10,000 gpd) employing chemical clarification, sludge conditioning/dewatering, and sand filtration of the effluent to be about $35/1000 gallons (1978). In addition to the difficulty in "breaking out" costs for dewatering alone, no data from existing installations are available.

Estimates for septage dewatering costs may possibly be generated using cost data for dewatering of liquid raw sludge containing 2 - 4% solids.

## References

1. Condren, A.J., "Pilot Scale Evaluations of Septage Treatment Alternatives," EPA Environmental Protection Technology Series, in press, 1978.

2. Medbo, F., "Operational Problems at Sewage Treatment Plants," Nordforsk (Nordic Research), Environmental Protection Secretariat Publication, No. 9, pp 259 - 274, 1975.

# SEPTAGE HANDLING AT A WASTEWATER TREATMENT PLANT

## LIQUID STREAM ADDITION

### Description of Process

Treatment by addition to the liquid stream of a sewage treatment plant is a common method of handling septage or holding tank wastes. In most cases, the material is discharged directly to the headworks of the plant in 1000 gal or more slugs. While this is certainly a simple procedure for septage disposal, it has been known to cause upsets in plant performance due to temporary hydraulic or organic overloads, clogging or fouling of plant equipment, or by exceeding the solids handling capacity of the plant. For this reason, a septage receiving station is recommended for the purpose of 1) allowing easy and safe transfer of septage from the hauler truck 2) providing some form of pretreatment (e.g., screening) to protect equipment downstream, and 3) allowing controlled addition from a holding tank into the desired process.

The first consideration is plant capacity, both aeration capacity (to handle the additional organic load) and solids handling capacity (to accomodate additional solids produced from septage during primary and secondary treatment). If plant capacity is very large in relation to the daily septage load (e.g., a 10 mgd plant handling two or three truckloads per day), holding and metering of the septage may not even be required. In some cases, slug septage loads at the headworks or into upstream sewers may have a negligible impact on plant operation. In most rural areas, however, sewage treatment plants have a limited capacity and may handle significant volumes of locally generated septage, necessitating the installation of a septage receiving/holding facility.

Most sewage treatment processes are able to treat septage; however some are some effective than others. Extended aeration plants, often found in rural areas, are able to handle septage relatively well due to the long detention time and the inherent resistance of the process to upset. Conventional activated sludge, preceded by a buffering primary clarifier, can effectively treat septage as long as organic and solids handling design capacity is not exceeded. Trickling filter plants are potential acceptors of septage; however, odor generation, filter fly proliferation, and media clogging may be a problem at increased organic loadings. Contact stabilization processes would appear to be least amenable to septage treatment due to the lack of primary treatment and the short contact time. Septage addition to the reaeration zone or aerobic digester (if employed) would be the preferred approach for such plants.

Figures 5 and 6 indicate the theoretical increases in sludge production and oxygen requirements as a function of volumetric rate of septage addition to a sewage treatment plant influent. Although the true increases will be a function of actual sewage and septage characteristics and flowrates, the curves show the increases to be substantial. For example, at a volumetric septage input of 1% of the plant flow, the theoretical sludge production and oxygen requirements for activated sludge plants can be expected to increase about 50 and 25 percent, respectively.

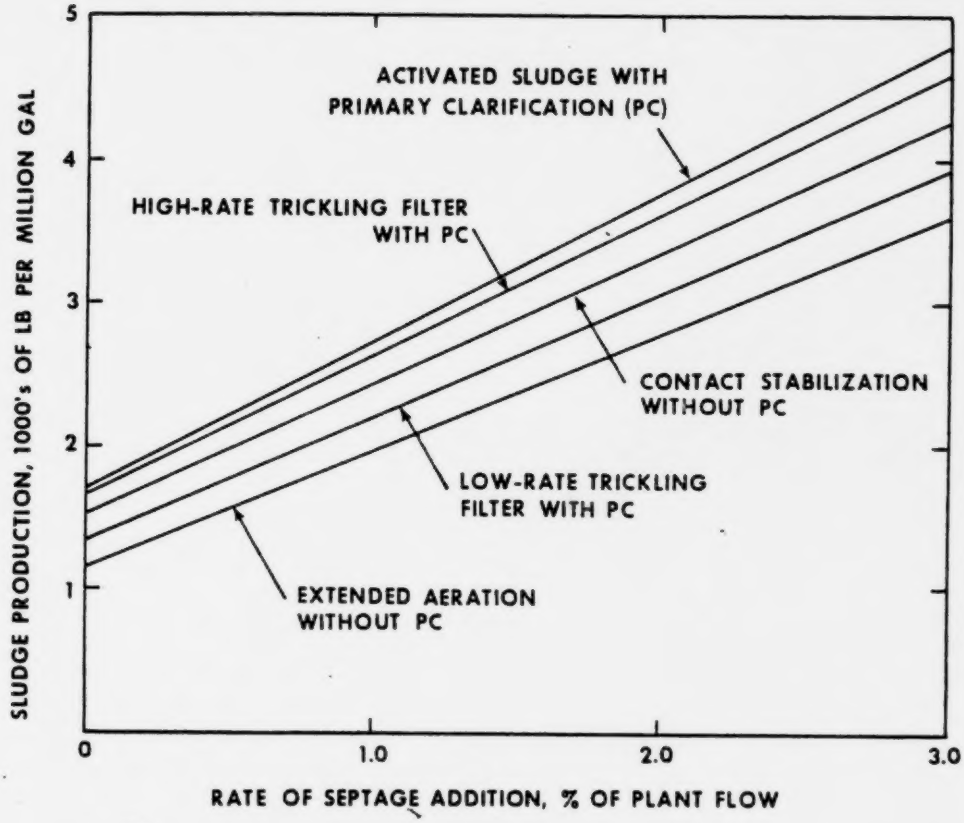

FIGURE 5. ESTIMATED WASTE SLUDGE PRODUCTION FROM BIOLOGICAL TREATMENT PROCESSES RECEIVING SEPTAGE

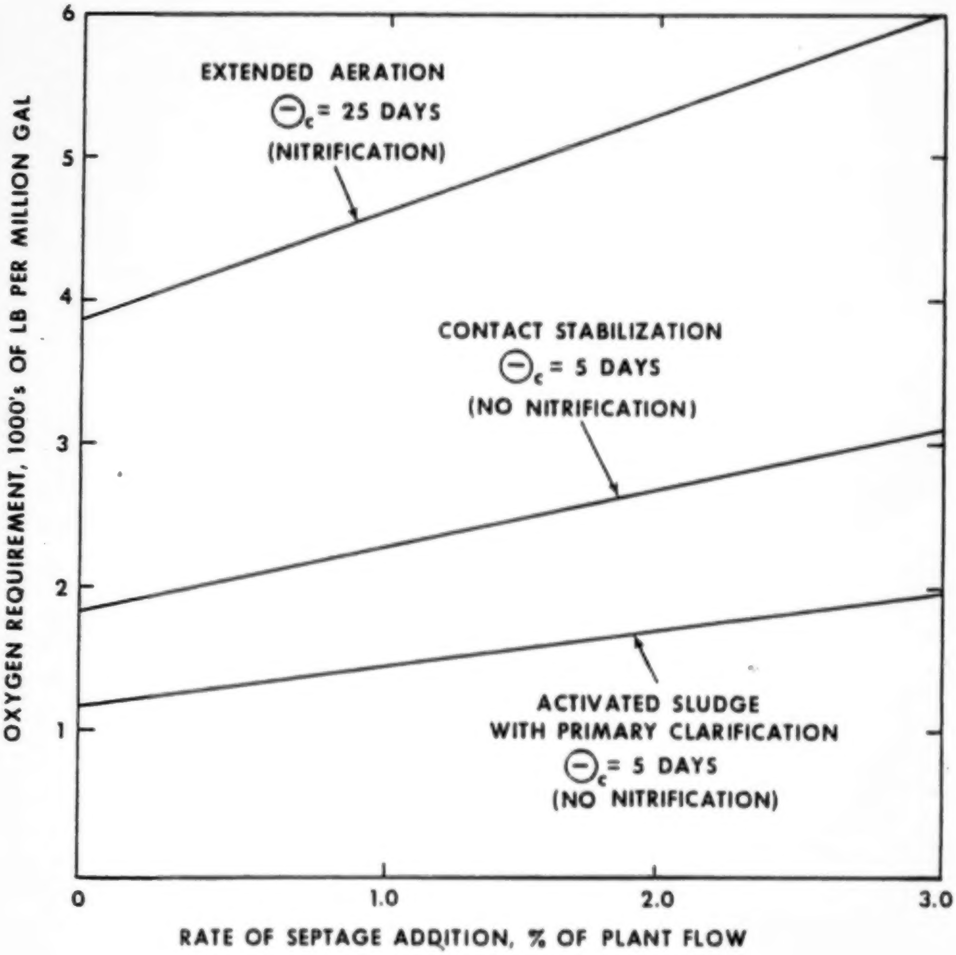

FIGURE 6. ESTIMATED OXYGEN REQUIREMENTS FOR BIOLOGICAL TREATMENT PROCESSES RECEIVING SEPTAGE

If a plant is of adequate capacity, detrimental effects on plant operation and performance can generally be avoided if proper pretreatment is provided. Coarse screening during discharge from the pumper truck is essential for removal of rags and large objects. A below-grade holding tank with a capacity of two days peak septage load is generally recommended. Next, a heavy duty sludge pump capable of handling semi-solid material is necessary. This pump should have a variable speed drive and/or an on-off control timer to meter the septage at the desired rate. Mechanical screens (40 mesh) have been used effectively in pilot studies for removal of hair, grease, and solids from septage. Such a device was found to be sufficient to prevent clogging or fouling of pilot scale equipment further downstream.

Aeration of the septage in the holding tank may provide sufficient mixing to allow a more constant loading to the treatment process; however, odors that are stripped out may be offensive and there is a potential for significant foaming of septage under aeration. Generally, preaeration to reduce the initial oxygen demand is not justified as this would be quickly satisfied in an aeration basin of sufficient aerator capacity.

Septage is often added to the plant grit chamber, as several investigations have noticed significant quantities of grit in septage. However, this may be associated with the pumping of cesspools rather than septic tanks. The degritting step may be warranted if grit is a particular problem in local septage.

## Design Considerations

1. Plant capacity-

   aeration--maintenance of proper D.O. at expected loadings
   solids handling--significant additional sludge

2. Sludge production-

   estimation of additional sludge production; chemical requirements labor costs; ability to handle increased quantities with existing equipment; disposal site

3. Operation and maintenance-

   may be increased substantially due to increased labor, power, chemicals

## Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Easily implemented | Additional sludge |
| Low capital cost | May exceed plant capacity |
| Convenient; public acceptance | Dilution followed by reconcentration |
| | Increased operation and maintenance requirements |

## Costs

Unfortunately, little field data exists on additional costs incurred by a sewage treatment plant accepting septage to the liquid stream. If expansion of the plant is not necessary, the only capital costs will be for the receiving pad, holding tank, ancillary equipment (pipe, pumps, valves, clean-up facilities), and any pretreatment such as screening or separate grit removal. Increased operating costs will be distributed among labor (additional operation of sludge handling equipment, septage pumping, screen and receiving station cleaning, monitoring of incoming pumper trucks and record-keeping, additional sludge transport/disposal), power (blowers for aeration basins, additional operation of sludge handling equipment, increased use of existing pumps, septage transfer pumps, blower for mixing contents of holding tank if utilized, additional fuel for transport and disposal of greater volumes of sludge), and possibly additional chemical requirements (sludge conditioning, chemical precipitation such as for phosphorus removal, and odor control if installed).

Capital costs for a septage receiving station at a sewage treatment plant vary widely according to complexity of design. For a large plant with relatively small septage input, a concrete pad and coarse screen may be sufficient. Most designs would include the pad, screen, holding tank, metering pumps, and clean-up facilities. More elaborate configurations might employ separate degritting, odor control, and additional pretreatment.

Many estimates have been generated for the total cost of septage treatment at a sewage treatment plant, ranging from \$2-\$38/1000 gal for specific applications. This author feels that the total treatment cost, including amortization of capital expenditures for a receiving station, probably falls in the range of \$20-\$30/1000 gal. Fees levied by sewage treatment plants for septage disposal are generally 30-60% of these values.

## Bibliography

Bowker, Robert P.G., "Treatment and Disposal of Septic Tank Sludges; A Status Report - May, 1977" in Design Seminar Handout: "Small Wastewater Treatment Facilities," USEPA Technology Transfer, Jan, 1978.

Cooper, I.A.. and Rezek, J.W., "Septage Disposal in Wastewater Treatment Plants," in Individual Onsite Wastewater Systems, Proc. of 3rd National Conference, Nina McClelland, Ed., Ann Arbor Science, 1977.

## SLUDGE STREAM ADDITION

### Description of Process

Addition of septage to the sludge stream at the sewage treatment plant may be a more logical way to treat and dispose of this waste. The main reason to consider this as an alternative to addition to the liquid stream is that the septage characteristics are more comparable to sludge than to sewage. The physical and chemical characteristics, as well as the microbial characteristics, are similar for septage and sludge. The addition of septage to the sludge handling system at the plant avoids possible problems with pumping, biological overloading, and significantly greater sludge volumes for final disposal. The sludge handling system may involve such processes as thickening, aerobic or anaerobic digestion, grinding, dewatering, and final disposal. Each of these topics, with the exception of anaerobic digestion, has been discussed in other sections of the handout. Anaerobic digestion has been employed successfully for septage-sludge mixtures on both pilot and full scale systems. The important point to be made in this discussion of septage addition to the sludge stream is that the burden of the septage loads will be placed on each sludge processing unit and that the capacity and effect on each unit must be considered when this alternative is chosen.

### Design Considerations

1. Volume of septage is critical to the capacity of sludge handling processes.
2. Organic and solids loading on each unit must be considered.
3. Pumping and holding capacity must be provided for incoming septage prior to blending with the sewage sludge.
4. Additional mixing and feeding equipment may be required.
5. An increase in chemical usage may be needed for additional solids processing due to septage.
6. Substantial increases in plant O&M can be expected.

### Advantages/Disadvantages

| ADVANTAGES | DISADVANTAGES |
|---|---|
| Overloading of secondary treatment systems avoided | May require additional sludge handling procedures or equipment |

| | |
|---|---|
| Avoids production of additional solids in secondary systems | Solids processing units may not have additional capacity needed for septage |
| Avoids dilution of septage with wastewater | Final disposal site must be expanded |
| Avoids possiblity of final effluent deterioration | |

## Costs

Costs have not been included for septage addition to the sludge stream due to the dependence on site specific characteristics of the treatment plant. Such characteristics would include size of plant, relationship of current sludge handling operations to sludge handling capacity, quantity of septage in relation to quantity of sewage sludge, type of plant sludge processed (biological, phsycial-chemical), type of stabilization and/or dewatering employed, chemical requirements, and mode of final disposal. Increases in labor, power requirements, and chemical conditioners (if employed) can be expected to be roughly proportional to the quantity of septage accepted.

## Bibliography

Condren, A.J., "Pilot Scale Evaluations of Septage Treatment Alternatives," EPA Environmental Protection Technology Series, in press, 1978.

Rotondo, V.J., "'Honey Wagon' Sludge Disposal," Water Works and Wastes Engineering, August 1964.

# "TREATMENT AND DISPOSAL OF RESIDUALS
# GENERATED FROM ON-SITE SYSTEMS"

Edited questions and answers following
Presentations by Mr. Robert P. G. Bowker
and Mr. Steven Hathaway
USEPA-MERL, Cincinnati, Ohio

AUDIENCE: Concerning subsurface injection, do you need any prescreening to get the plastics out?

MR. BOWKER: Yes, in all probability you will. I mentioned some of the problems associated with the general characteristics of septage. You do have bits of plastic. Hair is a problem in septage. These constituents may make pumping septage difficult. In addition, you have large solids and high concentrations of grease. Screening prior to application by one of the injection systems would be recommended because you may have a lot of problems due to plugging of valves and pipes caused by grease, hair and grit.

AUDIENCE: Regarding this trenching method, I'd like to ask you how much attention state officials should pay to contamination of ground water. I'm referring to the safe drinking regulations.

MR. BOWKER: It must be investigated. Unfortunately it's very seldom a consideration. It's a very simple procedure to dig some trenches and dispose of septage in this way, but if you're engineering systems to handle septage by this technique, certainly a very careful site evaluation would be recommended to try to determine if that soil would be capable, first, of handling it, providing the required renovation before it reaches ground water. By carefully selecting the site, bacteria and phosphorus should not reach the ground water. But I think in any designated septage land disposal area, ground water monitoring should be instituted.

AUDIENCE: One thing which is a concern to us, suppose we allow the trenching method. And they apply obviously at the higher rate than what nitrogen balance would indicate. And in a few years there will be, say a high nitrate leaching showing in the ground water; and what do we do at that time?

MR. BOWKER: At that point, there's not really too much you can do. In any land based system, the nitrate nitrogen is going to move through the soil. I think you can be fairly certain of that although you may get some denitrification and total nitrogen removal as it goes down through the soil. But nitrates may ultimately reach the ground water. And of course, with some of the other alternatives (besides trenching) involving larger application areas, the application is spread out such that you don't have a very concentrated point discharge to the ground water. But nitrate movement to the ground water is a consideration for all land based systems.

AUDIENCE: We require that septage be disposed of at a sanitary landfill in separate trenches. We have one county that is two percent private property; the rest is owned by the Forest Service. The Forest Service has said that they will not accept septage waste in their sanitary landfills. Are you educating the Forest Service that it may not be all that bad, that they should accept it?

MR. BOWKER: No.

AUDIENCE: You aren't?

MR. BOWKER: No, I'm not. EPA is not either. However, refusal to accept liquid wastes at sanitary landfills is quite common and may be well justified.

AUDIENCE: In Minnesota we have a similar county that is mostly owned by the U.S. Forest Service. And we've convinced them to set up places where we can drive back to their tree plantations and put septage in designated areas. And they've designated, I think, six areas in the county for surface application. Actually, they're using it for growing pine trees.

AUDIENCE: In Arizona they use a shorthaul method. It's dumped along side the road somewhere because the Forest Service won't accept it.

AUDIENCE: In Minnesota they've been very cooperative, at least on this. And I know in other counties, they've allowed them to use U.S. Forest Service land provided it's remote enough. And in most cases in Minnesota that's no problem.

MR. BOWKER: Certainly I would think that the surface application or even subsurface injection would be preferable to landfill disposal. From what we found, there's so much potential for leachate generation just because of its liquid nature that some of the other alternatives seem to be more appropriate.

AUDIENCE: It's not clear to me whether you're advocating stabilization prior to application. It appears that most of what you're talking about is unstabilized.

MR. BOWKER: That's a pretty ticklish question, and unfortunately I haven't been able to get a satisfactory answer from other people within EPA as to whether this requirement is going to be enforced or not. Right now I believe it's in fairly recently published proposed regulations that all sludges will be stabilized prior to direct land application. This does not seem feasible or justified in some cases because of the fact that they're remote areas and potential for contact is small. And to include the stabilization requirement would represent a fairly high cost. And the costs I've presented here do not include stabilization.

AUDIENCE: I point this out because in comparison to other means of treatment, the reception of septage from individual home systems must be included in the cost effective analysis. If you're going to include septage not only from a small community system but also from surrounding individual systems and compare this community system with other types of treatment, which might more readily accept septage into a treatment scheme, then the concentration analysis becomes one which sways very heavily towards the commercial treatment.

MR. BOWKER: That may be true. If the stabilization is required, it's going to be fairly costly. that's a good point. Right now it's up to the local agency as to whether they require stabilization of septage. But in an overall septage disposal scheme, this could add quite significantly to the overall cost.

MR. S. W. HATHAWAY: That was in a proposed regulation in the Federal Register, February 6, 1978 (vol. 43 No. 25). This is being worked on by the Office of Solid Waste Program. I think they're going to come out with a set of regulations on solid wastes which includes sludge and septage. We don't know what they're going to do.

AUDIENCE: I don't really agree with your slide there on contact stabilization. We had a plant where they wanted to put in a septage pump, dilute it, and put it through an aerobic process prior to going in. It was a plant design of .35 mgd and it accepted a thousand gallons of septage a day. In the contact stabilization plant, the solid concentrations in the stabilization zone were so high they couldn't operate the plant.

MR. BOWKER That's a good point. Extended aeration probably the one sewage treatment process that you want to keep septage away from, the main reason being that you have that very short contact time -- 30 minutes, 60 minutes at the most -- in the contact chamber. You have a problem with grease, solids, and soluble organics going right through the plant. Septage addition to a contact stabilization plant is generally not recommended.

Now there is a possibility of introducing septage to the reaeration or stabilization zone if you were to do it at a controlled rate. We've thought about that, although we've never had any projects that looked specifically at that. But that would be the only possibility I think for handling it in a contact stabilization plant.

AUDIENCE: Considering the new regulations regarding funding for these on-site systems, if we continue with septic systems.....I don't know what the general practice is in Illinois as far as disposal of the septage that's been pumped out by these fellows. Probably, in some cases at least, they just take it out somewhere where nobody's looking and get rid of it. Of course, it's an agricultural state, so you can get rid of it on farm land and I think the farmers are fairly interested in that. But if it does come to a situation where a lot of this is going on, I would think there's going to be more and more of this providing treatment for septage at existing facilities. If that's the case, it would seem to me it might be a good idea that the regulations provide additional plant sizing for that purpose. In other words, if you build a plant for a larger community, say, a 2 MGD plant, and it's in an area where there are a lot of unsewered communities nearby, it would seem to me that there should be some special consideration of whether there would be a need for additional capacity or not. It seems to me it's always easier to include everything at one time than to go back and piecemeal things together. You know, you go back and add this unit on or that unit on. Well, this would be the same kind of arrangement. I just wondered if there's any proposals that the regulations would indicate either a requirement for that or at least suggest that be considered as a planning procedure.

MR. BOWKER: I'm not aware of any, although there have been many plants designed to include the loading from septage and designs including a septage receiving and holding facility. I would assume that in the design they would consider the additional capacity required.

AUDIENCE: I'm talking about the assimilation of septage on land. How long after you abandon that land can you assure that runoff will not be contaminated?

MR. BOWKER: I think in Maine they recommend one year after use of the site for septage disposal, and generally it will revert back to a useful stage relatively quickly. Of course, it's going to depend what your application rate is, and actually how much you've applied in the season or over a period of years, but certainly that's something to consider. How long will the site not be useable for say, farm land or crop production?

MR. HATHAWAY: I think the most important thing when you're talking about sludge or septage surfacing is that it usually happens when rain occurs a few days afterwards. Once it gets into the soil, it gets a chance to percolate through some dry soil unless you get immediate wet conditions such as rain.

AUDIENCE: In the case of liquid sludge in Texas there's a couple of places I know of where by injection it using the equipment developed up here in Boulder, Colorado, and it's been very successful. There's tremendous biological activity in that soil. It's degraded very quickly. You don't have a problem or it doesn't appear that we have a problem with runoff. It's the activity, the degradation of the material is tremendous. This is digested sludge that's been injected. It's not totally stabilized, but the biological activity is tremendous, and it's a very rapid process.

AUDIENCE: What does the lime do to the drainage capabilities of dewatering capabilities?

MR. HATHAWAY: We have conflicting reports on that. The two different projects were done at Lebanon, Ohio. One of them was done with septage specifically, and we got a significant increase in dewatering. It helped dewatering, but that was on sand beds. This particular project I have addressed was a laboratory study with the vacuum filter and some mechanical detwatering units. They found that it actually made the filtration worse by adding that much lime. I don't know what I can say. Generally lime or ferric chloride is added to a sludge to improve filtration. So I would hope you would get improvement.

AUDIENCE: I think also the lagoon system, when you're relying on it for infiltration or dewatering, that if you're in any kind of proximity at all to ground water, that you're definitely going to have ground water contamination of nitrates. I think that's important to realize. If you're presenting this as something to use to handle septage, it's important to realize that you're going to have ground water contamination, and unless you recover that ground water by means of other drain systems or recovery wells and then subsequent treatment and discharge, you're going to have ground water contamination.

MR. BOWKER: I'd like to comment on that. When a site is selected for this type of lagoon system which relies on infiltration for dewatering, unfortunately they are often the ones with the coarser soils with the greatest potential for transmission of ground water.

MR. HATHAWAY: That's right, and it's certainly part of the cost to put in monitoring wells to keep an eye on this. A lot of these lagoons that I looked at in Connecticut were located in sandy soil, and they had looked at it pretty closely as far as the ground waters were concerned. They selected their sites very well. They were assured that they were a long ways from the ground water, and when they did look at the ground water they made sure that their wells were in the ground water flow, and most of the places that they have looked at....about seven or eight lagoons that I looked at....haven't had any gross contamination with nitrates. Now, again that has to be site specific depending on flow of ground water. You have a tremendous flow in there and the infiltration going into these lagoons may not be of significant impact, but that of course is the biggest consideration for these things. Even though they're low cost, the cost soars if you have to start putting in something to catch the under-drainage. You would hope to get considerable evaporation from these lagoons.

AUDIENCE: Does the compost get disinfected before you put it on the land?

MR. HATHAWAY: If the composting system is run right, the temperature gets up high enough to destroy pathogens. That's the whole idea behind it. I don't know whether this particular process gives a good mix and good temperature transfer.

# PRESSURE SEWERS

by

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## I INTRODUCTION

### 1. The significance

At the present time, over 1/4 of the population of the U. S. is not served by sewers. In many instances, septic tank - drainfield installations serve this population well, while in other instances sewers are generally desired. The cost of conventional sewers is often prohibitive, however. Typically, about 80% of the cost of sewers lies in the collection system, and only 20% in treatment. High costs are occasioned by:

- Deep excavation
- Rock
- Shoring
- Dewatering
- Tightly controlled alignment

### 2. Where applied

Pressure sewers might be considered to serve difficult areas where conventional sewers are impractical, uneconomical or otherwise infeasible:

- Sparse housing
- Slow growth areas
- Very hilly or very flat terrain
- Low lying homes

3. The process

Pressure sewers use a pump at each home or group of homes. May be a:

0 Solids handling pump (SH)

0 Grinder pump (GP)

0 Septic tank and effluent pump (STEP)

The main is a small diameter PVC pipe, laid like waterlines.

The small diameter is possible because:

0 Flows full

0 No infiltration into pressurized part of system

0 Need not accomodate root cutting equipment.

## II TYPES OF PRESSURE SEWERS

The on-lot facilities are available in a package, or a component system may be assembled.

1. Solids handling pumps

0 Will usually pass 2" sphere

0 Sometimes used to pump from low lying home to gravity sewer

0 Often used to sewer houseboats

0 Simple

0 Homeowner restraint is required. Control required on what is discharged to pump

0 High heads difficult to obtain owing to centrifugal pump affinity laws.

## 2. Grinder pumps

Also called "cutter" pumps. Grind or cut solids during pumping into a slurry. Similar to kitchen sink garbage grinder. This allows higher heads, less concern for problems with piping and pumping. Nice packages available, usually used as package system, not component. Single and duplex available. Two basic types:

- Progressing cavity pump - semipositive displacement (SPD), also called pro cav or Moyno type, Environment One Corporation.
- Centrifugal, by Hydromatic, Peabody Barnes, Myers, Toran.

## 3. Septic tank - effluent pumps

Used to avoid problems with grit, grease, stringy material in sewage and to allow use of inexpensive pump. Some partial package systems available, often component systems used.

- Centrifugal pump capable of 1/2" - 1" solids, most common. Hydromatic, Peabody Barnes, some others.
- Flexible impeller SPD pump with very light duty cutter. Seldom used. Jabsco.
- Centrifugal pump with solids deflector. Eco pump.
- Pneumatic ejector. Aeropump (Franklin Research) or Clow.

4. Discharge points

0 Pressure sewer system to STP

0 Pressure sewer system to gravity sewer

0 Low lying individual homes to gravity sewer

0 Pressure sewer system to community drainfield or other alternative system

0 Single home to drainfield, mound, sand filter, etc.

## III PIPING SYSTEM

### 1. General

As in water system practice, pressure sewers are shallowly buried just below the frost line or at a 24" minimum depth, and follow contours of the ground. Besides affording a lower cost, hillsides and other difficult to serve areas may be developed. Normally dendriform layout, not looped. Looped system may infringe on patent by Clift. Sometimes use looped with valves normally closed, STEP systems.

### 2. Piping materials

Almost always PVC water system piping. May be rubber ring joint or solvent weld joint. Rubber ring is often preferred because:

0 Solvent weld joints may require more skill in assembly

0 Rubber rings allow for pipe expansion and contraction.

PVC has a high rate of thermal expansion.

1/3"/100'/10 deg F which is 5 times that of steel or iron. PVC is available from 1/2" diameter to 12". Available either in "class rating" (working pressure rated) or "schedule series". Classes include 100, 125, 160 and 200 psi. Schedule series pipe has the same wall thickness as steel and the psi rating varies with diameter. As an example, schedule 40 1/2" pipe is rated at 600 psi while 8" is rated at 160 psi. Mains are usually class 125 or 160 or 200. Schedule 40 or 80 is used where mechanical strength is required, and schedule 80 may be threaded.

Table 1. PVC Piping Materials

| | | | |
|---|---|---|---|
| Class (working pressure rating, psi) | 125 | 160 | 200 |
| Standard dimension ration (SDR = OD/t) | 32.5 | 26 | 21 |

Schedule series: Schedule 40 and 80 - solvent weld joint only
Sizes available: 1/2" - 12"
Thermal expansion: 1/3"/100'/10 deg F
Hazen Williams "C" value: 140 conservative

On special order and with a slight cost increase, PVC may be colored distinctively (brown, yellow, etc.) to better distinguish the sewer from water mains. Often the pressure in water mains exceeds the shut off head of pressure sewer pumps, so unintended discharge to a water main is usually impossible.

The friction factor adopted for PVC used on pressure sewers is usually Hazen Williams C = 140 or 150. Battelle suggests 140 as conservative.

### 3. Installation

Plastic pipe may be damaged by scoring or "notch effect". In rocky soils, sand zone backfill is preferred. When crossing roads by boring or jacking, best to install conduit as casing for PVC.

### 4. Damage prevention

Locate main where damage is less likely. Place 14 gage copper wire with pipe so it may be located with toning equipment. Require accurate as-constructed plans. Place warning signs along pipe route and show offset to pipe. A good permit system for buried utilities will provide advance notice of excavation in proximity to sewer.

### 5. Maintenance and repair

Place shutoff valves at intervals. Gate valve, U valve or ball. When closed, centrifugal pumps go to shutoff head. Can run some time without overheating. Positive displacement pumps heat, trip out thermal overload. Then cool and try again. Need for cleaning is greater with SH or GP than STEP. If velocity too low, grease accumulates on crown of pipe. Can provide cleanouts along pipe route and use pipe cleaning "pig". These can serve also as evacuation stations. Thrust blocking is required at changes of direction for pressure developed when pigging, also pipe should be tested at 100 psi +. Need prompt, adequate repair force.

6. Air release

Required at precise high point of summits and occasionally between summits. Manifold to release air swept in direction of flow. Automatic valves serve purpose better than manual. Sometimes manual are used initially when system has been designed for much more than present usage, and automatic valves are fitted later.

Automatic valves should have corrosion resistant working parts. Type 316 stainless steel. Odor may be problem. If so, can vent gases to soil bed for treatment. When in hummocky terrain, consider placing pipe on constant grade rather than constant depth to minimize summits, as water line practice.

7. Flows

Usually 40 to 60 gpcd. No infiltration in pressurized portion of system. Design flows have been determined from:

0 Pressure sewer experience

0 Water system analysis during periods of minimal outside use

0 Conventional sewage flow minus infiltration and inflow, but with corrections for gravity sewer time of concentration. $T_c$ for pressure sewers = 0.

Design flows shown on figure 1 are from the following sources:

1) Battelle Columbus Laboratories. A family of curves was proposed based on people per home (EDU) and gpcd.

Used by Hydromatic and Peabody Barnes pump companies.

2) Environment One Corporation. Suggested design flow to be used with E-1, SPD type pumps.

3) Durtschi. Used by K. A. Durtschi, design engineer for two STEP (cent pump) projects at Priest Lake, Idaho and now serving 400 homes and 250 homes.

4) ASCE. Prepared from measurements of water system performance in the northeastern United States, also in California.

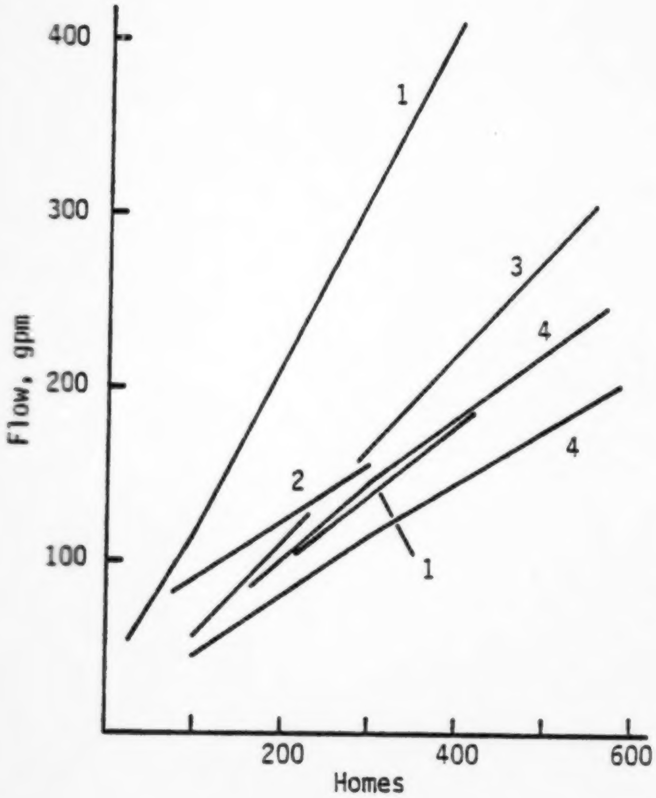

FIGURE 1
DESIGN FLOWS

Using midrange values from figure 1, assuming 3.5 people per dwelling unit and a velocity of 2.5 fps, table 2 may be used for planning purposes.

Table 2. Typical Main Sizes

| Population Served | Pipe Size |
|---|---|
| 250 | 3" |
| 500 | 4" |
| 1,200 | 6" |

8. Cleansing velocity

0 GP systems: Normally 2 - 5 fps desired. Grease forms on crown of pipe if too low. Can interfere with air release valve operation.

0 STEP systems: Generally less than 2 fps, sometimes ignored.

9. Cost

Costs vary greatly with geographic location, topography, design, etc. Those shown in figure 2 are 1978 prices from the Glide, Oregon project and include flushing, pressure testing, fittings, valves, cleanouts, air release assemblies, etc.

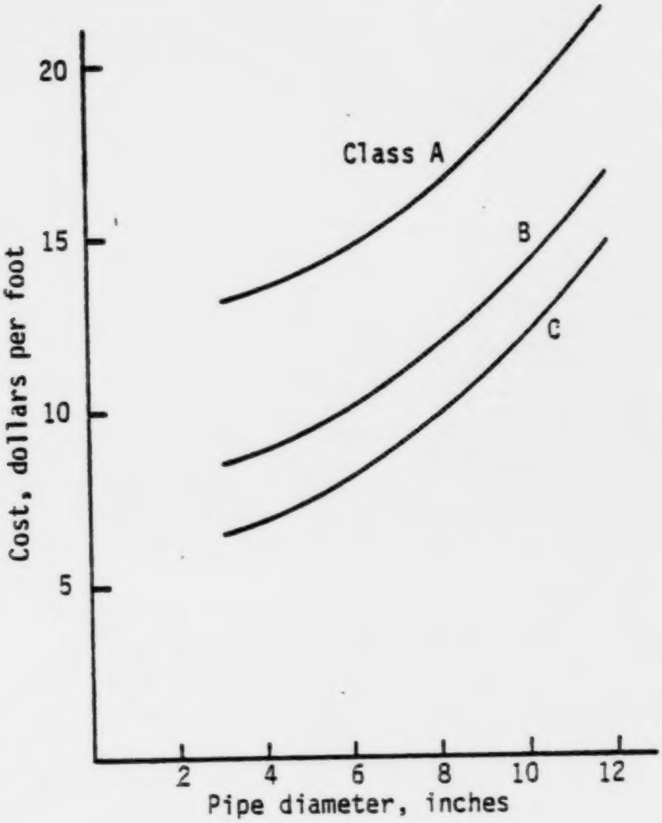

FIGURE 2
COST OF PRESSURE SEWER MAINS,
GLIDE, OREGON

## IV ON-LOT FACILITIES

### 1. General

Locate near home, short building sewer reduces infiltration potential. In cold climates, may locate in basement. Use cleanout on building sewer. Service line to main PVC, polyethylene or polybutylene, normally 1" to 1 1/2". Enter main with tee or saddle and corporation stop.

May place check valve near main. Damage is possible to service line by future excavation. Provide reserve space or overflow to existing drainfield. Infiltration may enter from drainfield, if high groundwater and if drainfield is not downslope from installation.

## 2. Electrical

Wafer breakers allow adding circuits to existing breaker panels. Power from home may also be taken from meter base if square, not round. If power is metered separately from home, the minimum charge for reading and billing exceeds cost of power used. Desirable to use large wire, 4 conductor, 230 V between source and pump panel.

0 Allows flexibility to use different sizes of pumps, perhaps in future.

0 Homeowner's breaker may be larger than one at pump panel.

Panel contains following minimum:

0 Relay (unless level controls will switch full wattage).

0 Alarm and silence switch.

0 Fuse or breaker, and separate alarm fuse. Pump fuse to be smaller than that in homeowner's panel, so the blown fuse is readily accessible to maintenance personnel.

0 Power disconnect, key lockable.

Power consumption is minimal.

Given:

| | |
|---|---|
| Flow | 200 gpd |
| Pump rate | 10 gpm |
| Motor | 1 hp |
| Power cost | 4¢/kwh |

Calculate:
7.5 kwh/month = 30¢/month

Power outages should be considered in alloting reserve space in vault. Outages are normally of brief duration. During outage water consumption is greatly reduced.

3. Grouping

When two or more homes are located near each other, may consider serving several homes with one unit. Advantages include:

+ Obvious cost savings.
+ System becomes less mechanical.

Disadvantages should be considered:

- An ordinance is required on misuse of system. Dental floss, plastics, ceramic dust, razor blades, etc. may be discharged. If a unit serves several homes, can't tell which home is violating.
- Longer building sewers are required, with more opportunity for infiltration. Difficult to determine which home is contributing.

- A cost reduction is given to the homeowner having the unit. Sometimes both will want unit, or neither will.
- If the home having the unit becomes vacant, power may be shut off.
- There is greater reliance on the unit.
- More reserve space is necessary, or emergency overflow to drainfield. Homeowners dislike thought of their drainfield being standby for other sewage.
- If the homes are at different elevations, it is possible during malfunction for the higher lying home to flood the lower home.
- Installations become nonstandard owing to different number of homes served.

If the plan is to serve groups or clusters of homes not under one ownership by a single unit, consult with title companies and lending institutions for their reaction. May place on public lands and system becomes more like conventional sewers.

### 4. Design features

0 Seek simplicity of design, minimize number of failure points.

0 Strive for design excellence. A single problem with on-lot facility design is multiplied by the number of installations.

0 Prefer equipment which fails soft.

Example: Level controls preferred where more probable failure mode is "off". High level alarm will sound rather than pump running to destruction.

0 Plan for uniformity in initial installation, project expansion and maintenance replacement. Simplifies maintenance.

0 Prefer universal vault design which can accept various kinds of equipment. Avoid reliance on single source equipment.

## V GRINDER PUMPS

### 1. General

Available in nice packages from various manufacturers. Simple for engineer to use and packages reflect improvements made from years of experience. An ordinance is required regarding the discharge of plastics, etc. which may cause malfunction of pump. Available either as semipositive displacement (SPD) or centrifugal.

### 2. Semipositive displacement

Environment One Corporation. Progressing cavity, Moyno type. 1 HP, 230 V, 1725 RPM. Near vertical H-Q curve simplifies hydraulic analysis. Capable of fairly high heads, 80', and can pump to 115' occasionally and briefly.

Overload trips out when excess pressure is developed, then cools and resets.

3. Centrifugal

Available from Hydromatic, Peabody Barnes, Myers, Toran. Normally 1 1/2 - 2 HP, 230 V, 3450 RPM. Heads to about 120 feet. Submersible. When a number of centrifugal pumps operate simultaneously into a common header (pressure sewer) all at different points and different elevations along the system, pumps do not share load equally. Design is that any one pump will not be dominated so long that sewage will rise to alarm level. Usually installed in vault using slide away coupling and guide rails, or suspended from vault cover.

4. Cost

Most probable purchase price for system:

0 Pump only $500 - $750

0 Basic (minimum) package $1150 - $1800

0 Installation -- varies

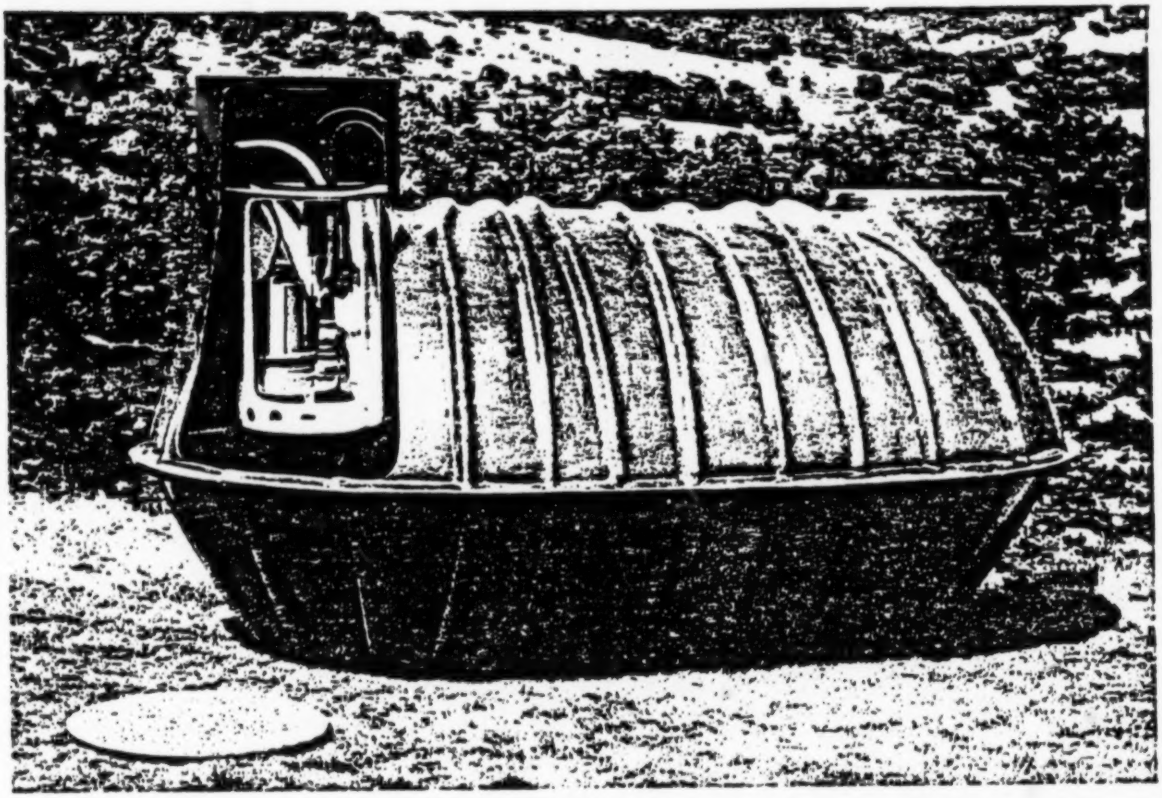

FIGURE 3

STEP INTERCEPTOR TANK, GLIDE, OREGON

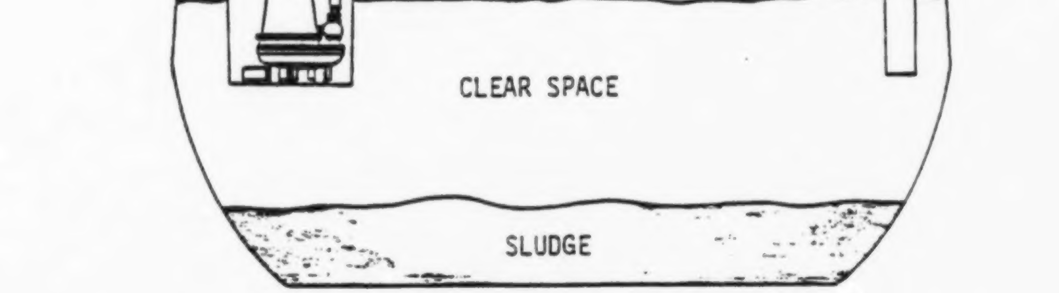
RESERVE SPACE
SCUM
CLEAR SPACE
SLUDGE

FIGURE 4

## VI SEPTIC TANK - EFFLUENT PUMPS

### 1. General

Sewage from the home flows to the septic tank for capture of grit, grease, stringy material which causes problems in pumping, then effluent flows to pump vault. Freeboard between the top of the scum mat and the soffit of the tank provides reserve space. Because grinding is not required, and large solids handling capability is unnecessary, pump is inexpensive but reliable.

### 2. Use of existing septic tank

When serving existing homes, considerations can be given to use of the existing septic tank. Advantages are:

+ Obvious cost savings

+ Construction disturbance to property is minimized.

Disadvantages include:

- Tanks are usually of very poor quality, and leak. In areas of high groundwater, infiltration can occur.
- Tanks are frequently of imperfect design. Reserve space may be too small, baffles may be missing, even barrels, etc. are found being used as septic tanks.
- Replacement with a new tank insures more uniform and proper design.

3. Septic tank design

Sludge accumulates and digests in the bottom of the tank. A minimum clear space is necessary between the top of the sludge and the outlet. Similar clear space is necessary for scum, which is partially submerged. Scum accumulates at the surface. Reserve space lies between the top of the scum and the soffit of the tank.

Sludge and scum accumulation rates are shown in figure 5 and are taken from (1) Dr. J. T. Winneberger, septic tank systems consultant, (2) studies by the Public Health Service, and (3) observations by Schmidt from 8 years experience with STEP pressure sewers.

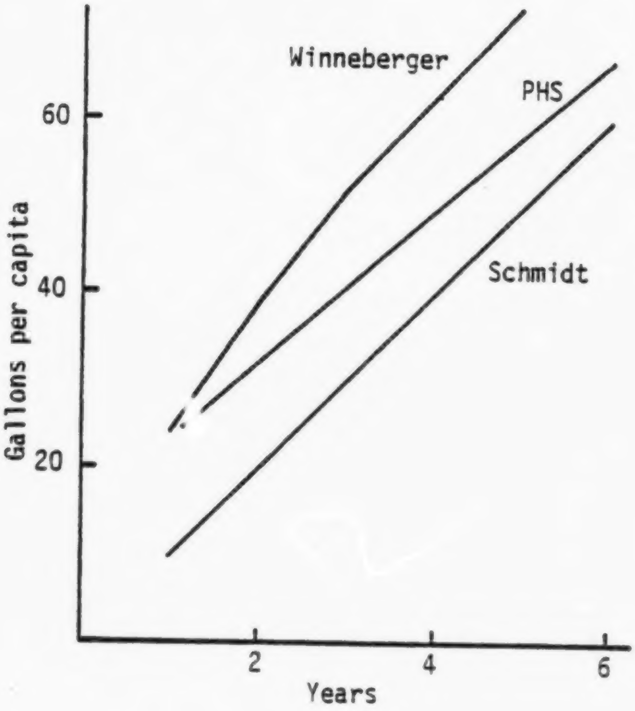

FIGURE 5
SLUDGE AND SCUM ACCUMULATION

Sometimes "interceptor tank" variations of septic tanks are used. One version is shown in figures 3 and 4. Here, effluent from the clear space flows to the pump through ports located peripherally in the pump vault.

## 4. Effluent pumps

Most commonly, submersible centrifugal pumps are used, ranging from 1/4 to 2 HP. These are usually capable of passing about 1/2" to 1" solids. The Eco pump is a pedestal centrifugal using a blade to deflect solids away, so has very small solids handling capability. Flexible impeller Jabsco pumps might also be used, which employ a very light duty grinder for what occasional solids may be encountered. Pneumatic ejectors are sometimes specified (Clow or Franklin Research), which feature very high head possibilities (250' ±) and fail soft at shutoff.

## 5. Cost

Varies geographically and with different designs.

- Pump only: $50 - $400
- Materials only shown in figure 3 & 4: $800
- Complete installation at home, including all labor and materials, furnishing power, locating and crushing old septic tank, service line and connection to main:

  Glide, Oregon: $2,000. $1,500 if existing septic tank is used.

Priest Lake, Idaho: $1,000 - $1,200.

Port Charlotte and Port St. Lucie, Florida: $730.

## VII TREATMENT

### 1. Characteristics

0 Little or no infiltration, so gpcd is lower than that ascribed to conventional sewers.

0 GP waste stronger than conventional sewage in mg/1, but weaker in ppcd.

0 STEP waste same as conventional sewage in mg/1, but weaker in ppcd.

Table 3. Generalized Average Sewage Strengths,
Conventional Sewers & STEP Pressure Sewers

| | | $BOD_5$ | | TSS | |
|---|---|---|---|---|---|
| Sewage | gpcd | mg/1 | ppcd | mg/1 | ppcd |
| Conventional | 100 | 200 | 0.15 | 200 | 0.15 |
| STEP | 50 | 200 | 0.07 | 100 | 0.04 |
| % Reduction | 50 | 0 | 50 | 50 | 75 |

### 2. Treatment considerations

Experience with the treatment of pressure sewer collected wastewater is limited, but has been good. Lack of infiltration is a benefit. No need for bar screen, comminuter, grit chamber (STEP) or influent pump. Because of odor potential, may be desirable to enter plant with submerged and diffused inlet.

Pretreatment has generally not been required, but caution would suggest being prepared to pretreat if necessary using air, oxygen, chlorine, hydrogen peroxide or ozone. Small scale treatment of STEP waste by sand filter has been very effective, normally BOD/SS about 5/5. When discharging to receiving gravity sewer manhole, septic waste sometimes presents problems: odor, corrosion, toxicity, flammability. When possible, enter manhole where receiving flow of conventional sewage is substantial. Bring pressure sewer into manhole such as to avoid turbulance. Anticipate pretreatment method in advance, use if found necessary.

## VIII OPERATION AND MAINTENANCE

### 1. Requirements

Homeowners maintenance is risky, also grant restrictions. Capable, well equipped staff is normally justified. One phone number desired, day or night. Need ordinance on disposal of plastics, etc. especially for GP systems. Homeowner responsible for negligent damage. Design such as to minimize need for routine maintenance.

Piping system:

- Furnish locates for utility companies digging in proximity to sewer.
- Exercise valves.

0 Clean air release assemblies.

0 May flush mains periodically.

0 Prepared to make emergency repair.

On-lot facilities:

0 May monitor infiltration by events counter.

0 Monitor negligent damage, ordinance violations.

0 Monitor septage, pump when required. (STEP)

0 Wash down vaults, remove grit. (GP)

0 Prepared to make emergency repair.

2. Imperfect design

Some maintenance requirements are inherent to pressure sewers, such as normal pump failure or damage to the shallowly buried mains. Other maintenance occurs from improper designs. Example: corrosion of a part which could have been made of noncorrosive materials. Provision desired whereby the correction of imperfect design is possible as part of capital investment rather than O&M.

3. Cost

Most sewerage system O&M is represented by customer accounting, billing, general and administrative, with a smaller part being actual sewer O&M. This is true of pressure sewers as well as conventional.

Pressure sewers are generally regarded more costly to maintain than conventional. They are certainly less tolerant of lack of maintenance. Typically, conventional sewers receive too little scheduled maintenance, but bypassing due to excessive infiltration is often allowed, and maintenance is deferred.

Quantum steps are taken depending on staffing requirements. Suppose two employees are needed to maintain a system of 500 pumps. At $1,200/month per employee, a cost of $4.80/month per pump results for wages alone. Add repair materials costs and amortize sunk cost of repair shop, vehicles, etc.

Maintenance frequency sometimes reported as the mean time between service calls (MTBSC). There is a MTBSC for pumps and another for the remainder of on-lot facilities, including level controls, etc. Reported MTBSC varies greatly. Usually reported about 1.5 years overall, and 4 years for pump. Some reports for pumps range to 37 years, based on only a few years' operation. Pump may have about 10 year life. Common to allow $3 to $10 per month for pump maintenance in perpetuity.

## IX COST EFFECTIVE ANALYSIS

Comparing gravity sewers to pressure sewers is comparing unlikes.

However, each capable of collecting sewage without nuisance or hazard to health. Conventional sewers are high initial cost, lower deferred cost and O&M. Pressure sewers have low front end cost, higher deferred cost. Population projections have considerable impact on analysis. Uncertainties of cost and O&M suggest assigning a range of values and range of population growth. Ask "what if" questions. Apply to ranking system. Use the old, mature practice of conventional sewers, unless savings are substantial. Don't underestimate cost of on-lot work for gravity sewers. Is cost included for crushing old septic tank on each system? Plumbing oriented to rear of house? Don't underestimate cost of maintaining gravity sewer, especially in areas of high groundwater. Is bypassing acceptable? Historical gravity sewer O&M costs may reflect deferred maintenance, anticipating rehabilitation programs.

## X INSTITUTIONAL

### 1. Easements

Usually general, "over and across". Similar to telephone, electrical meter, etc. Easement then follows facilities as monument once installed. Sketch made of each. Map location of septic tank, drainfield, buried utilities.

Sketches of on-lot facilities become part of contract plans.

Inducement for homeowner to sign:

0 Grant provides low cost to "initial user" as opposed to "subsequent user".

0 Assess "system costs" whether home is connected or not. Include mains and STP, but not on-lot facilities.

0 Pressure sewer releases property committed for drainfield and replacement area for second drainfield.

0 Condemn.

## 2. Requirements of district

Is the district regarded a talented owner? Ability to analyze and correct imperfect designs? How is future expansion and equipment replacement controlled to avoid an excessive mixture of designs and equipment? Make district aware of special considerations. A letter reply to concerns may prompt consideration.

## 3. Requirements of engineer

Pressure sewer design not yet commonly known. Higher engineering requirements and cost on first system, especially if component. Not engineering by code alone. Desirable to have predesign report, also post construction report. Encourage visit to an operating system.

### 4. Assessments

Because of low cost per foot for pressure mains, can afford to pass property. Low cost infrastructure. Need not vary assessment with frontage, acreage or valuation. Coordinate with Assessor. Commercial charges may be made based on flow by using events counter. Consider social acceptance if two or more homes share one pump.

## XI ENVIRONMENTAL

+ Less disruption occurs in trenching for pressure sewers as compared to conventional.
+ Pressure sewers need not follow strict alignment. Freedom in routing may create less damage than conventional.
+ In extreme topography where conventional sewers are prohibitively costly, pressure techniques may provide only sewerage alternative.
- Line ruptures can occur. However, bypassing (as conventional sewers) due to excessive infiltration is obviated.
- Odor potential is greater than with conventional.
- Greater disturbance on-lot, especially when replacing septic tanks in STEP application.

## XII SUGGESTED REFERENCES

1) J. F. Kreissl, "Pressure Sewers", U.S. EPA Technology Transfer publication, 1977.

2) Design manuals by Environment One Corporation, Hydromatic, Peabody Barnes, and Myers (pump companies).

3) Study for U.S. EPA by Rezek, Henry, Meisenheimer and Gende, Inc. Maintenance and treatment emphasis. Not yet in print.

4) Pressure Sewer Capsule Report for U.S. EPA by W. C. Bowne. Not yet in print.

# "Pressure Sewer Systems"

Edited Questions and Answers
Following Presentation
By Mr. William C. Bowne
Roseburg, Oregon

AUDIENCE: So your only real consideration, then for pressure sewers, is just to get below the frost line?

MR. BOWNE: Well, yes, there is one other consideration...a couple, I guess. One is getting it deep enought that you are less likely to incur damage from other utilities. Another one is if you are wanting to cross your water lines with some minimum amount of clearance, say 12 inches or 18 inches, and if you have a lot of crossing, then you might bury it deeper, just so that you are not constantly having to dip under water lines.

AUDIENCE: I wondered whether or not you have any experience with pressure sewers to indicate that with constant grade and no air release valves you might have air production from the septic waste that you are handling?

MR. BOWNE: That's a very good question. We have done jar tests on that. We can't get production to amount to much so we hired Dr. Pomeroy, maybe you are familiar with his work on sulfides,...to analyze that because of all the work he had done forced main. He concluded that it did not come out of solution. I still have a curiosity myself as to whether gases can be liberated in the main.

AUDIENCE: What happens when a pipe or a pump is not used for six months in a summer home or something like that? Does it corrode?

MR. BOWNE: Yes, if a pump sits idle or a person is gone from their home for six months or so, with some pump designs you will form an iron sulfide that will sort of fix the impeller to the casing. It isn't fixed very tightly. You can turn the impeller with a screwdriver but these pumps have very small starting torques. So little that the pump motor can't start up the pump so it will trip out the fuse and the system will overload just like that...and you will get a service call.

Now, interestingly enough, if you use a bronze impeller you still have the same problem. So I think the answer to that would be plastic. Plastic performs beautifully, speaking of septic wastes. Just really beautifully. Brass is very, very bad. Brasses will dealloy. Some bronzes are okay. Stainless steel type 400...terrible. 300 series is good and, especially, again, 360 and 304. In many cases we are not really using a pressure sewer pump, a pump that was conceived and designed to be a pressure sewer pump. We are using something else. We are using a cellar drainer, an adaptation of a sewage pump or something that works all right. It is acceptable but in the future I would expect to see more plastic parts.

AUDIENCE: If you feel that there have to be some tests conducted, wouldn't you rather rely on some tests done by an agency like NSF for grading?

MR. BOWNE: I would rather satisfy myself on the quality control. Some of these tanks have UPC stickers on them. It doesn't mean a thing. It means the drawing said it was right and when they dropped in the tanks looked okay but out of the first 60 tanks we got, we rejected 60. Not all at once. At first we rejected about 30 of them and then as we checked the others over more thoroughly, we rejected them all.

We installed a few because we were so short on time. They failed. Well, mostly it was quality control. Shooting of glass, applying the resin, rolling it out, but also because they were using additives to their resin. They just burst. They cracked and ruptured. They would not get structural collapse but if you are in high ground water, you are going to get infiltration. But now this tank is a very good tank. You can buy them but you have got to be sure you have a good supplier and a retired lieutenant colonel for an inspector. Which is what we have.

AUDIENCE: Would there be much advantage to the two compartment unit?

MR. BOWNE: Dick Otis could probably answer that better. I think that here where we are not concerned so much with getting the finest quality effluent possible, because probably we are not discharging to a great deal, but we are interested in capturing grit and grease and stringy material. My experience so far is that this does a beautiful job of that. Plugging of the pump, for example, would be one of your concerns. And, we had one pump plug, and it had a glove in it. And, the only way that glove got in there, I am sure, is that it was left in there in the vault by the workmen. At Priest Lake, now, let's see, five hundred pumps installed in 1974. In four years we never had one plug. So, it is pretty uncommon with a decent design, to have a pump plug.

AUDIENCE: What kind of cleaning velocity do you recommend for the step system?

MR. BOWNE: Well, I wish I had a really good answer for that. I don't have. All I can say is I have never seen any need to clean a step system pipe line. I have never seen any accumulation other than just a very light film that you could feel with your fingers. I know that Australia uses, in some instances, those small diameter gravity sewers that convey only septic tank effluent. They have developed a standard of 1.5 feet per second. If deposition of solids in the main were much of a problem, drain fields never would work because drain fields don't have cleansing velocities in them. I don't think that drain field failures are often attributed to the drain field itself filling with solids. I realize it has the clogging of the trench size but not one of filling the pipe line with solids. I think that what solids are there, you know, and certainly there are suspended solids in the effluent, are pretty light and filamentous, pretty easily transported. I wish I really knew but I think it can be just nearly ignored.

# THE COST OF SMALL COMMUNITY WASTEWATER ALTERNATIVES

BY

James F. Kreissl
Robert Smith
James A. Heidman

# I. INTRODUCTION

## General Information for Estimating Costs

A number of sources of information are available which will enable the reviewer of 201 plans to evaluate cost estimates for alternative on-site disposal systems. Some of these publications and the types of information they contain are as follows:

### 1. Engineering News-Record

The ENR provides monthly updates of construction material prices and wage rates for 20 American and 2 Canadian cities. It also provides quarterly summaries of a number of indices including information from the Bureau of Labor Statistics and EPA. Selected examples of information of interest are shown in Tables 1, 2, 3, and 4.

Table 1. Materials Prices*

| Item | Unit | Atl. | Balt. | Birming. | Chicago | LA | Pitts. |
|---|---|---|---|---|---|---|---|
| Gravel, 3/4" | Ton | 3.85 | 4.00 | 2.95 | 3.00 | 5.60 | 8.55 |
| Sand | Ton | 4.74 | 3.35 | 4.00 | 2.55 | 5.60 | 8.15 |
| Crushed Stone | | | | | | | |
| 1 1/2" | Ton | 5.00 | 3.15 | 2.65 | 3.50 | 5.60 | 8.60 |
| 3/4" | Ton | 5.35 | 3.45 | 2.65 | 3.50 | 5.60 | 9.40 |
| Ready Mix Concrete | | | | | | | |
| 3000 psi | CY | 29.25 | 31.90 | 31.75 | 30.00 | 30.25 | 36.25 |

*In dollars as of June 8, 1978

Table 2. Wage Rates*

| Classification | Birming | Bost. | Dallas | Detroit | LA | S Fran |
|---|---|---|---|---|---|---|
| Heavy Construction Common Labor | 7.36 | 9.28 | 6.02 | 11.45 | 12.20 | 13.49 |
| Tractor Operator Including Dozer | 10.17 | 13.06 | 10.35 | 14.20 | 15.13 | 14.78 |
| Dump Truck Driver Less than 4 $yd^3$ | 7.43 | 9.49 | - | 10.96 | 12.68 | 13.40 |

*In dollars per hour as of June 1, 1978 including fringe benefits

Table 3. Piping Costs*

| Item | Atl | Bos | Den | NY | Pitts |
|---|---|---|---|---|---|
| Clay Sewer Pipe | | | | | |
| ASTM C700 8" | 1.79 | 1.79 | 1.73 | 2.75 | 1.82 |
| 12" | 3.87 | 3.86 | 3.90 | 5.75 | 3.91 |
| 24" | 18.40 | 18.40 | 14.15 | 17.25 | 17.85 |
| Asbestos Cement Pipe | | | | | |
| CL 2400 12" | 8.88 | 3.63 | 4.02 | - | 4.75 |
| Concrete Sewer Pipe | | | | | |
| ASTMC 76 12" | - | 7.50 | 4.35 | 6.65 | 5.55 |
| Drain Tile Clay, C-4 | | | | | |
| 6" | - | 1.90 | 1.20 | 0.50 | 0.49 |
| 8" | - | 3.40 | 1.73 | 0.64 | 0.71 |

*Construction costs in dollars per foot, FOB city shown, as of May 11, 1978

Table 4. Average Hourly Construction Industry Wages and Fringe Benefits*

| Trade | $/Hr |
|---|---|
| All Trades | 12.40 |
| Bricklayers | 12.77 |
| Bldg. Laborers | 9.94 |
| Carpenters | 12.62 |
| Electricians | 13.65 |
| Plumbers | 13.77 |

*As of January 3, 1978
Nationwide averages

## 2. Federal Register

The Davis Bacon Act requires that the advertised specifications for every contract in excess of $2,000 must state the minimum wages to be paid various classes of laborers and mechanics. These wage rates and fringe benefit rates are periodically updated by the Department of Labor and are published in the Federal Register as Minimum Wages for Federal and Federally Assisted Construction. The rates for each state are detailed by county and in some cases for individual cities and various zones within the city. Should it be necessary to obtain more detailed information on wage rates than provided in ENR indices, that information is available in the Federal Register.

## 3. Construction Cost Estimating Manuals

There are a number of construction manuals available which enable one to determine typical crew sizes, outputs and unit costs for various tasks. The following manuals, which are updated annually, are quite useful:

a. Dodge Guide for Estimating Public Works Construction Costs, McGraw-Hill, Information Systems Co., 1221 Avenue of the Americas, NY, NY 10020

b. Means Building Construction Cost Data, Robert Snow Means Company Incorporated, 100 Construction Plaza, Duxbury, Mass. 02332

c. Building Cost File (Four Regional Editions are Available), Construction Publishing Co. Inc., 2 Park Ave., NY, NY 10016

The information contained in and the organization of each of these manuals are somewhat different. However, they all provide sufficient information on the material and labor rates used to develop their cost estimates that it is relatively easy to adjust the estimates to a specific set of conditions if desired. Examples of some of the types of information contained in these manuals can be seen by considering a few specific items.

The Means Building Construction Cost Data (1976) contains the information shown in Table 5 for the costs associated with installing (excavating and backfill costs must be estimated separately) polyvinyl chloride, class 160, SDR 26 water distribution systems:

Table 5. PVC Pipe Installation Costs

| Pipe Size Inches | Crew | Daily Output Lineal Feet | Costs Per Lineal Foot Material | Installation | Combined* |
|---|---|---|---|---|---|
| 1 1/2 | B-20** | 300 | 0.35 | 0.90 | 1.25 |
| 2 | B-20 | 250 | 0.45 | 1.10 | 1.55 |
| 3 | B-20 | 250 | 0.75 | 1.35 | 2.10 |
| 4 | B-20 | 200 | 1.15 | 1.35 | 2.50 |
| 6 | B-20 | 180 | 2.30 | 1.50 | 3.80 |

*Excavation and backfill costs must be added to obtain the total cost

**A B-20 crew corresponds to 1 foreman at $12.75/hr, 1 plumber at $12.25/hr and 1 laborer at $8.45/hr.

The Means Building Construction Cost Data (1975) indicates that trench excavation with a trencher should cost $\$1.35/yd^3$. For a trench 12 inches wide and 3 feet deep, this corresponds to 15¢ per lineal foot. The Building Cost File (1976 Central Edition) indicates a 12 inch trencher working in normal soil should cost $\$1.50/yd^3$ or 16.7¢ per lineal foot at 3 ft depth; costs for trenching in medium clay were estimated at $\$1.85/yd^3$.

Obviously, the individual cost estimates in any 201 facilities plan will vary with materials selected, previous experience of the engineering firm providing the estimates, local conditions, etc. However, since many of the on-site systems or small collection systems consist of a relatively few components or unit operations it is possible to utilize the above sources of information to independently evaluate the reasonableness of the cost estimates for various alternatives in a relatively short period of time. These sources of information can be used to supplement those provided in the other sections of this paper.

## II. COLLECTION SYSTEMS

Recent information resulting from the analysis of costs of several years of construction grant projects indicates that the cost of wastewater collection (gravity sewer) represents between 80 and 90 percent of the total construction cost of wastewater collection and treatment facilities. The above study, Construction Costs for Municipal Wastewater Conveyance Systems, EPA 430/9-77-014, MCD-38, when adjusted to the first quarter of 1978, can be shown to fit the following relationship in small communities.

$$C_c = 4406\ P^{-0.1976} + 203.1\ P^{-0.0896} \qquad (1)$$

where $C_c$ = capital cost, \$/capita
P = Population

Included in the above cost are engineering fees and contingencies. To obtain construction costs the non-construction costs must be deleted. The multiplier of construction costs to obtain capital costs is generally 1.25 to 1.30. In this discussion the factor 1.27 will be employed.

In performing a cost-effectiveness analysis, the entire cost of a project must be employed in comparing alternative designs, whether or not these costs are eligible for EPA construction grant funding. This analysis employs present worth comparisons, i.e., all capital and annual costs reduced to a present worth basis.

For the purposes of this discussion, i.e., comparisons of collection technology on an abstract (non site specific) basis, several empirical relationships are useful. Population density can be grossly related to community population by the following relationship:

$$PD = 0.30\ (P)^{0.304} \qquad (2)$$

where PD = Population density, persons/acre
P = Community population

From this relationship it can be seen that communities of less than 3,500 population will have densities ranging from less than one to about four persons per acre.

From the above study report (MCD-38) and its companion document, Construction Costs for Municipal Wastewater Treatment Plants; EPA 430/9-77-013, MCD-37, a relationship between the capital cost of conventional sewers and the capital cost of centralized treatment facilities for small communities can be estimated. This relationship is tabularized in Table 6 for three community sizes, assuming waste stabilization ponds as the treatment and 100 gal/cap/day as the design flow.

Table 6. Cost of Collection/Total Project Cost

| Population | Collection \$ (k) | Lagoons \$ (k) | C Coll/C Total |
|---|---|---|---|
| 100 | 198 | 27 | 0.88 |
| 1,000 | 1,250 | 208 | 0.86 |
| 3,500 | 3,500 | 625 | 0.85 |

If mechanical secondary or aerated lagoon treatment is assumed, these ratios drop only about 0.05 in each case.

For the purposes of comparison with alternative technologies of collection, the capital cost of conventional gravity sewers have been found to vary between \$2,000 per capita at a population of 100 to \$1,000 per capita at a population of 3,500, the PL 95-217 upper limit for small communities. If 3.5 persons per home are assumed, these estimates become \$7,000/home and \$3,500/home, respectively.

For the purposes of comparison with other collection technologies a community population of 500 is assumed which yields a capital cost estimate of \$4,900 per home.

Operation and maintenance (O/M) costs vary tremendously, but a figure of \$500 to \$1,000 per mile per year is generally acceptable. Again for the purpose of comparison, \$750/mi/yr is chosen herein, which can also be expressed as about 14 ¢/ft/yr. This figure does not account for lift stations or service lines, but does include administrative costs.

## PRESSURE SEWERS

Over the past decade, the concept of pressure sewers has evolved as a less expensive means of collecting wastewaters in rural areas, particularly where other mitigating factors (high groundwater, rocky terrain, hilly topography) accentuate the already high cost of conventional sewers. In analyzing cost information on both pressure and gravity sewers, it can be shown that the most important factors which affect the ratio of present worths of pressure sewer systems to conventional ones are population density and the cost of on-lot facilities. Low values for either of these parameters will enhance the cost advantage of pressure sewers.

Population density and population are inversely related to the required length of conventional gravity sewers on a per capita basis. The equation

$$L = 118.1\ (P_D)^{-0.1976} \qquad (3)$$

where $L$ = length of sewer, ft/capita
$P_D$ = design population

clearly shows that in rural (low population) areas much longer sewer lengths are required to serve each home. Since the cost of installing pressure sewer mains is a fraction (1/3) of the corresponding cost for conventional mains, the increased length/capita accentuates this cost advantage. Typically, installed mainline pressure sewer pipe costs less than \$10/ft due to low pipe and labor costs, as opposed to conventional gravity sewers, which cost from \$20 to \$55/ft, due primarily to labor costs. Another advantage inherent in pressure sewers is the potential reduction in pipe length requirements due to their flexibility of location.

The cost of on-lot pressure sewer facilities normally constitutes the majority of the pressure sewer capital cost. Therefore, it is extremely important to consider a variety of on-lot alternatives consistent with aesthetic, engineering and public health standards of the community in order to hold these costs to a minimum. Over and above the basic technological requirements for on-lot systems, other alternatives such as multiple homes on one pumping system and various alarm and pump failure contingency designs can have profound influence on the overall cost of on-lot facilities.

It is impossible to properly break down the capital cost of a pressure sewer system because of the site specificity of each installation. However, for the purpose of determining sensitivities, Table 7 may provide some insight for a conservative initial pressure sewer cost per home in a case where one STEP unit/home is employed. All new septic tanks are required, the length of pressure sewer main required is the same as gravity mains, and 3.5 persons/home and population of 500 exist.

Table 7. STEP Pressure Sewer Cost Estimate

| Component (Quantity) | Installed Price | Total |
|---|---|---|
| Septic Tank (1) | $400 | $400 |
| STEP Unit & Ancillary Items (1) | $1,350 | $1,350 |
| Service Line (100 ft) | $3/ft | $300 |
| Mainline (120 ft) | $5/ft | $600 |
| Ancillary mainline | $75 | $75 |

Total construction cost = $2,725/home

Total capital cost = $3,460/home

The above talbe again reinforces the relative importance of the on-lot costs (3/4 of construction cost), particularly the pressurization system itself, in the overall capital cost determination. It also serves to show the potential for reduced cost by conversion of existing home septic tank-soil absorption systems (ST-SAS) to pressure sewer systems and, especially, by using one pressurization system for more than one home.

In the above example, the cost of septic tanks and building sewers is dealt with under on-site systems; the cost of installed pressurization (STEP) units with ancillary components has been reported to vary from about $1,000 to $2,000; service lines generally vary from $2.00 to $3.00/lineal ft; total mainline costs are dependent on local conditions and required ancillary equipment such as air release valves, cleanouts, and other valves and appurtenances which could increase mainline costs by as much as 20 percent. The estimate for a GP pressure sewer system would be similar except that the cost of the septic tank would be generally offset by a higher cost for the GP unit and ancillary items.

Operation and maintenance (O/M) costs must also be separated into mainline and on-lot components. Mainline O/M is generally categorized as preventative maintenance and repairs. Recently acquired data indicate that both mainline categories vary widely for existing systems, but are generally quite low. Insufficient data at this time make any set of O/M estimates less than satisfactory, and reported estimates vary from $100 to $200/yr/mi.

The annual on-lot O/M costs can tentatively be broken down as shown in Table 8 for a STEP system. Power costs are based on reported figures.

Table 8. O/M Costs - STEP

| Category | Annual O/M Cost Estimate |
|---|---|
| Pump operation (1/3 hp) | $1.20/yr |
| Septic tank pumping (4 yr) | 10.00 |
| Pump repair | 20.00 |
| Preventative maintenance (1 hr/yr) | 10.00 |
| Appurtenance repair | 10.00 |
| Total | $51.20/yr |

Similarly, the annual on-lot O/M costs of a GP system can be tentatively broken down as shown in Table 9.

Table 9. O/M Costs - GP

| Category | Annual O/M Cost Estimate |
|---|---|
| GP operation (1 hp) | $4.00/yr |
| GP repair | 50.00 |
| Preventative maintenance (1 hr/yr) | 10.00 |
| Appurtenance repair | 10.00 |
| Total | $74.00/yr |

The preceding breakdowns are based on general trends of records of several installations, but even for these limited installations the figures vary from negligible to several hundred dollars per year for individual units. Therefore, the important fact to be noted is that GP systems generally require greater O/M expenditures than STEP systems.

## SMALL DIAMETER GRAVITY SEWERS

Technologically, these systems are small diameter sewers which transport septic tank effluent by gravity at a minimum velocity of 1.5 ft/sec when flowing one-half full. A minimum slope of 0.0067 has been suggested, along with a minimum pipe size of 4 inches. For U.S. practice Otis (1978) suggests that a 0.003 slope is sufficient.

Although very little U.S. experience is available for use as a cost guide for small diameter gravity, recent construction grant project costs for conventional gravity sewers can be extrapolated to develop a gross estimate of the total per capita cost for these systems. Construction cost for gravity sewer pipe is expressed as follows:

$$C_c = 2.54 (D)^{1.1667} \qquad (4)$$

where $C_c$ = Construction cost, \$/ft

D = Pipe diameter, inches

Since a 4-inch pipe flowing one-half full at required slope can carry 42,300 gal/day, it is likely that most small community installation would be served by a high percentage of this size of pipe. Using a design population of 500 and equation (2), the length of sewer per capita is found to be 35.2 ft. Using equation (4) the construction cost per capita is estimated at \$12.80/ft, and at a sewer length of 35.2 ft/capita results in a mainline sewer cost of \$451 per capita. The ancillary costs given by Dames and Moore (MCD-38) for this size pipe are 98¢/ft. Since insufficient data are available to significantly alter this figure, \$1.00/ft is assumed in this example.

The following table estimates the per capita and per home (assuming 3.5 persons/home) capital costs of small diameter gravity sewers for a new development with a design population of 500 where ideal topography exists:

| Component | Installed Cost (\$/Capital) | Total Installed Cost (\$/Household) |
|---|---|---|
| Septic Tank | 114 | 400 |
| Mainline Construction Cost (4 inch gravity sewer) | 451 | 1,578 |
| Ancillary Cost | 35 | 122 |
| House Connection (100 ft) | 143 | 500 |
| Construction Cost | 814 | 2.600 |
| Capital Cost | 1,032 | 3,300 |

An equivalent conventional sewer for the same theoretical community would cost approximately \$1,400 per capita, or \$4,900 per home.

The O/M cost of small diameter gravity (SDG) sewers is relatively unknown based on their recent introduction into the U.S. As previously noted, the O/M cost for gravity sewers has been determined to be about \$300-\$1,000/mi/yr. This figure includes lift stations of which fewer will be required for SDG systems due to reduced slope requirements. Therefore, it might be expected that the O/M cost of SDG sewers is slightly less than this figure, of about \$500/mi/yr. The on-lot O/M is essentially the cost of septic tank pumping, or about \$10/yr/home.

## VACUUM SEWERS

Vacuum sewers have been technically described earlier as having the following major components:

1. On-lot valves, controllers, and ancillary equipment.
2. Trapped mainline piping
3. Vacuum station, including vacuum pumps, tankage, discharge pumps, standby power, and ancillary controls and devices

In the first two cases a similarity exists to pressure sewer systems, while the last case offers some similarity to conventional sewer lift station technology.

Cost information is extremely sparse for vacuum sewers owing to their infrequent use in the U.S. and their application to private developments where cost information is difficult to obtain. For the on-lot portion, the major portion, the major components are the sump and the valve, sensor, controller and their housing. The only reliable cost which recurs is the cost of the valve assembly at $500 each. Installation including air breathers, sump, etc., can vary from $150 to $650. On-lot piping to convey the waste to the valve would normally cost from $200 to $400, i.e., the same as a normal house connection.

Mainline piping requirements are similar to pressure sewers, except that pipe grades must be maintained, pockets and cleanouts are employed and stronger pipe (SDR 21 vs SDR 26) is required. Actual quantification of this difference is difficult, but a few pieces of information are available. For example, pocket and cleanout installation costs have been reported at about $100 each, and their required separation distances are a function of topography. For the purpose of comparison a 400 ft separation is assumed. Also, 4 inch SDR 21 pipe costs about 35¢ more per foot than 4 inch SDR 26. Since the labor cost represents about one-half of the pipe and additional labor is required to meet grade requirements, some additional increase for cost will result over pressure pipe installation. A cost of $7.50 per foot is assumed in this estimate, which would appear to be a reasonable assumption in light of the previous estimates of $5.62/ft and $14.20 for presssure and SDG mainline costs, including ancillary equipment.

Vacuum stations have been installed in existing systems for $30,000 to $75,000. At Bend, Oregon this cost was subdivided as follows:

| | |
|---|---|
| Structure | $11,000 |
| Equipment | 25,000 |
| Electrical | 6,000 |
| Total | $42,000 |

This system had a capacity of 50 homes. Also, some discharge piping or force main cost must be added to deliver the sewage to its terminal destination. In this example, no cost is allocated to this highly variable component.

Based on the above information the following estimated initial costs per household can be proposed for a community of 500:

| | Installed Cost | Total Cost ($/home) |
|---|---|---|
| Valve and Appurtenances | $900 | 900 |
| Service Line (100 ft) | $3/ft | 300 |
| Mainline (120 ft) | $7.50/ft | 900 |
| Vacuum Station | $75,000 | 525 |
| Total Construction Cost | $2,625/home | |
| Total Capital Cost | $3,336/home | |

As with pressure sewers, there is considerable potential savings by using multiple homes per valve, thus reducing the considerable on-lot cost (almost 50 percent of total construction cost).

The operation and maintenance (O/M) problems of vacuum sewer systems have had a poor history. In very recent times, equipment manufacturers have seriously undertaken improvement in component and system design and operator training. Therefore, it is extremely difficult to quantify O/M costs, because the data base represents older equipment and practice. However, an attempt can be made based on the required O/M functions which include preventative maintenance, operation, and repair of valves, mainline and vacuum stations. Valves should be inspected on a yearly basis, and will generally require unscheduled repair every 4 to 8 years, and should be given a complete inspection and servicing about every 6 years (more often in hard water areas). Mainline operational requirements have been suggested to be in the range of one to 3 man hours per year per home served. Repair and replacement of station equipment has not been documented, but the vacuum and discharge pumps could certainly be expected to require major overhaul or replacement in ten years. Finally, the power requirements for vacuum systems have been shown to vary from 0.0024 to 0.44 kwh/gallon of sewage transported.

Based on the above, a tentative yearly estimate for vacuum sewer O/M for a community of 500 people appears as follows:

| Category | Cost |
|---|---|
| Operation and Preventative Maintenance (5 hr @ $10/hr) | $40/yr |
| Power (170 gpd @ 5¢/kwh and 0.01 kwh/gal) | 31/yr |
| Repair and Replacement | 14/yr |
| Total | $85/yr |

It is notable that the power cost for system operation represents a significant portion of the yearly O/M cost per home. This fact, recognizing that its absolute magnitude may change considerably depending on design and local topography, points out one of the major drawbacks of vacuum sewer systems, i.e., their energy-intensiveness.

## ALL COLLECTION SYSTEMS

As can be easily ascertained from the above exercise with an ideal terrain, all three alternative collection systems have similar capital cost advantages over a conventional gravity sewer in excess of 30 percent. As the terrain becomes more undulating the relative capital cost advantage of pressure and vacuum sewers increases. As higher lifts become necessary vacuum sewers may become inappropriate leaving the greatest capital cost advantage to pressure sewers alone. Operation and maintenance costs must be included in any realistic comparison in order to truly evaluate the cost effectiveness of each type of system.

Recognizing the impossibility of comparing alternative collection systems without having a complete set of physical constraints, the following discussion is designed to illustrate several points with regard to the relative merits and drawbacks of these systems. The areas discussed for comparative analysis are topography, geology, population growth, adaptability to hybrid designs, potential environmental impacts, treatment implications, and climatic effects.

1. Topography - The effects of hilly terrain on conventional sewer costs are well known. Similar effects can be expected for SDG sewers. Vacuum sewers are limited in their available lift due to the limits of vacuum itself. Pressure sewers are clearly the system best capable of handling wastewater collection in hilly areas. However, even these systems can become significantly more expensive under some undulating conditions. The cost of air release valves, flow sustaining valves and lift stations can add significant expense to a pressure sewer, albeit less than would be expected for the other collection systems. Actually, the ideal pressure sewer situation is one where a continuous upward slope is encountered.

2. Geology - For the sake of this discussion, geology includes groundwater, soil and rocky strata within the soil mantle. As previously noted, conventional sewers can be greatly affected by high groundwater due to the need for extra shoring and well-pointing in order to facilitate the manpower in the trench. SDG sewers, although piping is lighter and easier to handle, have similar requirements and are similarly affected. Pressure and vacuum sewers are generally laid just below the frostline and, except for extremely cold areas along the northern borders of the U.S., are far less affected by conditions of high groundwater or bedrock than are the deeper gravity sewers. In colder regions insulated pipe had been employed successfully at lesser depths.

3. Population Growth - Vacuum and pressure sewers have significant on-lot cost which suggest that the economic advantage of these systems increase where the initial population is significantly smaller than the design population. Gravity systems are designed and built to serve a design population, although in small communities a sufficient reserve may result from administrative constraints on minimum pipe diameter to permit even larger populations to be adequately served. This ability to handle flows above the design population contribution is not inherent in SDG sewers if the 4 inch diameter requirement is permissible by local codes. In fact, assuming a 75 gpcd peak flow, an SDG sewer (minimum specification of 4 inch diameter PVC at 0.0067 slope will handle a population of about 564 people flowing one-half full. Vacuum systems can be deleteriously affected by a small Po/Pd because of inefficient operation during the initial years after construction, resulting in greater power costs per gallon of sewage transported. Pressure sewers, however, have the ability to operate well below and well above nominal capacity with only minor changes in operating and design methods.

4. Adaptability to Hybrids - As shown in the following table, conventional gravity sewers are adaptable as receivers in combination with any of the other sewer systems although some concern for sulfide concentrations may require special transition arrangements when pressure or SDG feeders are involved. In addition, it is unlikely that more than one type of mechanical (pressure and vacuum) system would be employed in a hybrid design for a small community. STEP pressure systems have been combined with SDG sewers at Westboro, Wisconsin, but the optimization of this combination could take several different forms. The problem relates to a STEP pressure feed SDG sewer and involves the need to avoid surcharging the latter, causing backup into the laterals. By oversizing the SDG sewer in the immediate zone of the connection this has been avoided (Otis, 1978). Since both types of sewers carry septic tank effluent, they should otherwise be quite compatible. Vacuum sewers would not be compatible with SDG sewers due to their discharge pumping design which would create surcharging in the latter. Possibly, small SDG or STEP pressure sewers could feed into a vacuum line without mechanical problems, but a potential odor problem might result in the air exhaust from the vacuum station. There are no data on this possibility.

5. Potential Environmental Impacts - This brief discussion considers only the potential primary impacts. Conventional sewers are known to leak and can thus pollute groundwater and cause significant disruption of the environment during construction. SDG sewers employing PVC pipe with O-ring joints are less likely to leak as much as the larger diameter gravity pipe primarily due to the longer pipe lengths and fewer joints of the smaller pipe. The two major types of known sewer malfunctions (blockage and breakage) have differing effects. Breakage in a gravity line is likely to increase the groundwater pollution potential. This is insidious in that it may go undetected for long periods. Any break in pressure sewers would likely result in problems in the area of the break but would be more obvious due to the likelihood of surfacing. The short term pollution potential of pressure system is greater than for the gravity system. Vacuum systems would move the problem back to the sources of the wastewater, i.e., sewage would back up into the homes as the laterals filled. A blockage in a mainline pipe would result in similar backing up for the gravity and pressure systems, but more severe problems could result in the latter due to pump operation above shutoff heads. However, the likelihood of blockage in pressure and vacuum systems is remote.

6. Treatment Implications - The effects of infiltration and inflow on conventional sewers have often been documented. The pressure system would deliver less wastewater to the treatment facility because no infiltration occurs while the vacuum system should deliver either the same or slightly more wastewater than is generated at the contributing homes. The SDG sewer would not be subject to manhole infiltration and inflow. Therefore, the treatment plant is likely to receive the following relative effluent characteristics from the alternative collection systems:

| Type | Flow | Waste Strength | Corrosive |
|---|---|---|---|
| Conventional | High | Medium | No |
| GP Pressure | Low | High | Medium |
| STEP Pressure | Low | Low | Very |
| Vacuum | Low | High | No |
| SDG | Med. | Low | Very |

The implications of these waste characteristics on treatment plant design are not completely clear at this time, but GP pressure sewer wastewaters like those from vacuum sewers are clearly stronger than conventional sewer wastewaters, but do not appear to present special treatment problems. The septic tank effluents carried by STEP pressure and SDG sewers are somewhat unique in that they have been pretreated and are directly amenable to secondary treatment. In terms of cost all the alternative systems should be less costly to treat due to their reduced flows. The differences in effluent characteristics may modify the savings accruing from reduced treatment facility hydraulic sizing.

7. Climatic Effects - Cold climate is unlikely to significantly affect conventional gravity of SDG sewers except in certain extreme cases due to their burial depth. Pressure and vacuum sewers, with their frost depth burial, are generally free of any mitigation except in the northern border states from Montana to Maine and Alaska. In these areas, the increased depth requirement may reduce their mainline cost advantage, but new materials are available to prevent the need for higher pipe laying costs. Warm climates may have some adverse effects on the odor potential of pressure and SDG sewers, but experiences in Florida show that good hydraulic engineering should minimize this problem.

## SUMMARY

The above sewering alternatives each have special features which may enhance or preclude their utility to the design engineer preparing a facilities plan. The above information is presented as a guide to both the designer and the reviewer to help determine the most cost effective solution in any given community.

# III. ON-SITE SYSTEMS

## SEPTIC TANKS

A septic tank can be used in conjunction with soil adsorption systems, mounds, pressure sewers, etc. The required tank size varies somewhat from state to state but generally averages about 1000 gallons per household. Because of the variability in septic tank design (material type, baffle arrangements, inlet and outlet configurations, number of compartments, etc.) as well as the variability in local markets and number of local manufacturers, there will be some natural deviation in tank costs. However, the delivered cost of a 1000 gallon tank should normally be around $200-$250. The installed cost of the tank including piping to the house generally ranges from about $350-$500.

Information from Building Construction Cost Data (1976) for precast septic tanks is as follows:

| Tank Size | Bare Material Cost |
|---|---|
| 1000 gal | $160 |
| 2000 gal | $375 |
| 5000 gal | $1500 |

It can be seen that there is no economy of scale in purchasing larger size precast tanks. According to Otis (1978) for tank capacities above 1800 gallons cast-in-place tanks are generally more economical in Wisconsin.

The operation and maintenance costs associated with the septic tank are generally estimated as just the cost of pumping the tank. Estimates of required pumping frequency reported in the literature vary widely. In general, estimating the pumping frequency at once for four years would seem reasonable. Nationwide pumping charges generally vary from $20 to $100, with a norm of about $40.

## SOIL ABSORPTION SYSTEMS

Soil absorption systems (SAS) normally follow a septic tank although they can also follow aerobic units or other pretreatment units. The cost is directly related to the size and type of absorption system. Soil classification, percolation rates, state and county regulations, site topography, and individual design preferences, materials and procedures all interact to control the size and cost of the SAS.

SAS costs can range from a low of around $300 to as much as $2800. Unit cost estimates for distribution boxes, leaching pits, leaching field chambers, trench excavation, etc., are provided in Building Construction Cost Data (1976). Similar information is also provided in some of the construction pricing and scheduling manuals.

### Septic Tank-Soil Absorption Systems

The delivered cost of a 1000 gallon septic tank normally ranges from $200-$250, and the installed cost, including building sewer, will normally be between $350-$500. The remainder of the cost is that associated with constructing the drainfield.

The installed cost of a trench or bed drainfield varies with the amount of area required. Since there are a number of design procedures and approaches which can be used, it is unrealistic to provide cost estimates for all design variations. Any proposed design and cost can be checked against the procedures and requirements of applicable state and local codes or those presented in the Manual of Septic Tank Practice to evaluate the reasonableness of the cost estimates. The following example illustrates how the total monthly cost per household can be calculated.

## INDIVIDUAL HOME SEPTIC TANK-TRANCH FIELD SOIL DISPOSAL

### Design Basis

75 gal/day per person
2 persons/bedroom
3 bedrooms/household
1000 gallon septic tank volume
trench field bottom area per bedroom (A, sq ft) versus percolation rate (min/in) from the following relationship:

$$A = 66.94\ (\text{min/in})^{0.389}$$

### Cost Estimating Relationships

Base date: first quarter 1978
Septic tank service life: 50 yr
Trench field service life: 20 yr
Interest rate: 6.625 percent
Installed septic tank cost: \$350-\$500
Trench field soil absorption system: \$1.00-\$2.10/sq ft bottom area
Maintenance cost: \$40 every three years

### Total Monthly Cost Per Household

Septic tank: \$2.00-\$2.80 per month
Maintenance cost: \$1.11 per month
Trench field: $\$/\text{mo} = (\$1.53\text{-}\$3.22)(\text{min/in})^{0.389}$

Total cost/household versus percolation rate:

| Min/in | Total Monthly Cost |
|---|---|
| 5 | \$5.99-\$10.00 |
| 10 | \$6.88-\$11.89 |
| 20 | \$8.05-\$14.33 |
| 40 | \$9.56-\$17.51 |
| 60 | \$10.66-\$19.82 |

Actual costs reported for conventional septic tank-soil adsorption systems (ST-SAS) vary over a range of \$600 to \$3,200. The major components of a ST-SAS for a three bedroom home are shown in the table below, along with some typical quantities and costs for each component. It is clear from this table that the greatest cost lies in the SAS, especially in the marginal or poorly permeable soils where larger systems are required.

### Conventional Septic Tank-Soil Absorption System
### (3 BR Home)

| Component (Quantity) | Installed Price | Total |
|---|---|---|
| Inspection and Design | $250 | $ 250 |
| Permit | 75 | 75 |
| Building Sewer and Septic Tank | 450 | 450 |
| Soil Absorption System (375-1,000 sq ft) | 1.50/sq ft | 562-1500 |
| ST-SAS Total | $1,387-$2,275 | |
| Reported Costs (All Homes) | $600-$3,200 | |

Since the SAS generally represents the major cost factor, further breakdown of the SAS subcomponents reveals that thereis a significant effect on the total cost by the width of bucket employed to dig the trench. Assuming a 30 inch deep trench requiring approximately 18 inches of gravel, 12 inches of backfill, and a four inch perforated drain pipe, the cost per lineal foot varies from $1.84 for a one foot wide trench to $2.81 for a three foot wide trench. This estimate is based on information obtained from construction cost estimating manuals and compares reasonably well with the actual range of experienced costs from the field, i.e., $1.50 to $4.40. Converted to a square foot of bottom area basis, the one foot side trench costs $1.84/sq ft, and the three foot wide trench costs only $0.90/sq ft. These costs also generally agree with the reported range of actual field costs, which vary from $1.00 to $2.10/sq ft of bottom area.

### Soil Absorption Systems

| Component (Price) | W = 1 ft | W = 3 ft |
|---|---|---|
| Excavation (85¢/ft) | $0.85 | $0.85 |
| Gravel ($4.80/cu yd) | 0.27 | 0.80 |
| Pipe (50¢/ft) | 0.50 | 0.50 |
| Backfill (60¢/cu yd) | 0.02 | 0.06 |
| Misc Labor (20¢/sq ft) | 0.20 | 0.60 |
| Total ($/ft) | $1.84 | $2.81 |
| Reported | ($1.50 - $4.40) | |
| Total ($/sq ft) | $1.84 | $0.90 |
| Reported | ($1.00 - $2.10) | |

Close scrutinization of the SAS cost breakdown reveals that the cost of gravel can also cause a significant change in this typical example. As shown previously, the cost of gravel can vary by nearly a factor of three and the labor cost by a factor of two between major U.S. cities. Since these two constituents each account for about half of the total installed cost of gravel and the cost of gravel accounts for 15 to 30 percent of the cost of the soil absorption trenches, a significant difference in system costs between different geographical areas can result.

## Absorption Beds

Soil absorption beds are sometimes used instead of trenches because of their lower construction cost and reduced land area requirements. The former factor is generally minor in that the only appreciable savings would be in the pipe lineal footage requirement. Since this was previously shown to represent less than 20 percent for a three foot wide trench, overall savings could be expected to amount to anywhere from 0 to 10 percent. The land area savings result from the maximum use of the bed area, i.e., 300 square feet of bottom area can be provided in a 300 square area of land. Conversely, trench systems generally are limited to a three foot width and require 6 to 9 feet between trenches. As a typical example, 300 square feet of bottom area would require a land area of about 17 feet by 18 feet, while a three foot wide trench system (2 trenches) with a six foot trench separation requirement would need a land area about 600 square feet. Employing piping specifications from the MSTP (three feet from wall and six foot separation), the savings in pipe would be 110-50 or 60 feet. At 50¢/ft this saving would amount to about $30 for the bed, as compared to a typical price for the trench system of $400, or less than 10 percent.

Because of their inherently poor hydraulic patterns which concentrate waste flow in a minimum-sized area, increasing groundwater pollution potential and clogging potential, and their traditional construction patterns which involve the travel of heavy machinery on and/or over the infiltrative surfaces, absorption or seepage beds should be generally restricted to coarser soils, such as sands, sandy-loams, etc.

## Dosing Systems

Recent research has often pointed out the value of dosing a SAS, as opposed to naturally occurring or "trickle" dosing. Although definitive/quantitative results are not yet available, the concepts of equal distribution and dosing appear to result in both a reduction of potential groundwater pollution by microbiological and chemical pollutants and a lengthening of the service life of the SAS.

In terms of economics, dosing can be accomplished through the use of a dosing siphon, if sufficient head is available, or a pumping chamber. Dosing siphons cost about $200, but installed costs vary from $00 to $600 for a simple home system. A pump chamber with controls can cost anywhere from $600 to $1,000 depending on the design. Generally, a small (1/2 to 1/3 hp) submersible sump pump is employed which appears similar to a STEP system for pressure sewers. The type of control system employed can vary from a volume control, generally off-on mercury float switches, which pumps an equal, pre-set volume to the SAS each time to a timer control (with a low-level shutoff) which activates the pump at pre-set time intervals. In any case, O/M costs resulting from the use of pumping chambers would be $20 to $50 per year.

In coarse-grained soils, it is imperative to provide reasonably uniform distribution to the infiltrative surface to prevent localized overloading and potential groundwater contamination. In fine-grained soils (clays), the distribution should be accomplished naturally when dosing in a gravel filled trench. In the former case, the use of small-diameter (2 inch) plastic pipe with specially drilled holes (Converse, 1974) is desirable to insure proper distribution. In the latter case, the natural distribution through the porous gravel in the trenches may often suffice.

In light of the above, the following tabular listing of the increased costs of dosed/uniformly distributed soil absorption systems is provided.

| Item | Installed Cost | O/M |
|---|---|---|
| Siphon (4 in) | $400-600 | - |
| Pumping System | 600-1000 | $20-50 |
| Drilled Pipe | 0.15/ft | - |

Therefore, the additional cost to a three bedroom home ST-SAS for uniform distribution and dosing could vary as follows (assuming three foot wide trenches):

| | |
|---|---|
| 1. Conventional ST-SAS (5 min/in = PR) | $1,387 |
| (head available-siphon + pipe) | $1,806-$2,006 |
| (O/M increase $0) | (30-45%) |
| (head not available-pump + pipe) | $2,006-$2,406 |
| (O/M increase $20-50/yr) | (45-75%) |
| 2. Conventional ST-SAS (60 min/in = PR) | $2,275 |
| (head available-siphon) | $2,725-$2,925 |
| (O/M = $0) | (20-30%) |
| (head not available-pump) | $2,925-$3,325 |
| (O/M = $20-50/yr | (30-45%) |

The above data for a typical installation indicate that a substantial increase in capital costs will result if dosing and distribution are required. They also clearly illustrate the negligible cost of the drilled, small-diameter pipe and the desirability of locating system components in such a way as to utilize available head for siphon dosing.

## Alternating Beds

Another concept which has exhibited considerable success in California, Virginia and other locations is the concept of using two separate fields, using one while resting the other. Again the definitive/quantitative evidence which is required to determine the field sizes, number of fields, and the required period of rest for different soil types is yet to be produced, but present information is overwhelmingly positive. Thus, alternating beds are considered a viable alternative to conventional SAS designs. Without the quantitative relationships described above, state and local regulations may require anywhere from a standard SAS split into independent absorption units to two full-size SAS units. In all cases, an alternating valve is employed to direct the flow from the septic tank to either unit. There are a few different valve designs available, and these vary in cost (installed) from $100 to $200.

All alternating bed systems are based on the principle of infiltrative capacity restoration with time and accompanying oxidation of the clogging material in a trench. As noted above, the relationship between climate and soil type and required resting period is yet undefined, but one-year resting periods have proven successful in several cases.

The economics of alternating beds vary with code requirements. The following table represents a matrix of two soil types (5 and 60 min/in perc rates) and two code extremes (split-bed and two-bed requirements) and assumes a three bedroom home and $150 for an alternating valve:

| Soil PR | Split | Double |
|---|---|---|
| PR=5 min/in | $1,537 | $2,099 |
| ($1,387 Conv) | (11%) | (51%) |
| PR=60 min/in | $2,425 | $3,925 |
| ($2,275 Conv) | (7%) | (73%) |

The above table clearly shows the need to develop definitive criteria for designing alternating beds. If indeed a split system will suffice, an exceptionally long-lived system could be attainable for only about 10 percent more than present ST-SAS designs. Also, the alternating step which takes only a few minutes, would not significantly add to existing O/M costs. Presently, USEPA is sponsoring a study at the University of Wisconsin which is aimed at producing definitive data on this type of system.

## Mounds

Mound disposal systems take several different forms and names. They are usually used when one of the following conditions exists:

1. High groundwater (<3 ft)
2. Thin soil over creviced bedrock
3. Slowly permeable soil (<3 ft)

A mound is designed to provide treatment and distribute the wastewater over a wide area in a uniform manner. In fact, these two functions are interrelated because treatment would be deleteriously affected by poor distribution. Therefore, an effective mound incorporates dosing.

The cost of mound construction is highly dependent on the local cost of sand, gravel and fill/topsoil cover. For example, the two-trench, 300 gpd mound system with three feet wide trenches (Converse et al., 1976) on 0% slope would be 65 x 42 ft at the base with a peak mound height of 3.5 ft. To construct this system requires approximately:

| | |
|---|---|
| 12 | tons of gravel for trench |
| 265 | tons of sand |
| 110 | tons of clay fill/topsoil |
| 82 | ft of 1 inch PVC pipe |
| 48 | ft of 2 inch PVC pipe |
| straw or marsh hay | to cover the top of the trenches |

Assuming costs for each of these items would produce the followng tentative breakdown:

| Item | Quantity | Installed Unit Cost | Cost |
|---|---|---|---|
| Gravel | 12 ton | $4.80/ton | $58 |
| Sand | 265 ton | 4.80/ton | 1,272 |
| Fill | 110 ton | 2.00/ton | 220 |
| 1 inch pipe | 82 ft | 0.65/ft | 53 |
| 2 inch pipe | 48 ft | 0.65/ft | 31 |
| Grading, shaping, planting, plowing, etc. | | | 400 |
| Layout and supervision | | | 300 |
| Total | | | $2,334 |

Although the above approach is somewhat crude, it serves to illustrate that the greatest single cost factor is the sand. Given the threefold variation in the cost of sand between Chicago and Pittsburgh, it is not surprising that mound systems of this type are quoted to cost anywhere from $2,500 to $5,000. Adding the above mound cost to a conventional septic tank and pumping chamber for dosing/distribution yields a total cost of about $3,900 which is consistent with the above range. Otis (1978) expresses the range of mound costs as $0.75 to $3.00/sq ft of basal area. In the above case, a cost of about $1.50/sq ft resulted, also consistent with his nomenclature.

## ATMOSPHERIC (EVAPORATIVE) DISPOSAL

Much has been written about the use of evapotranspirationfor the disposal of on-site wastewater effluents. Obviously, there are areas of the U.S. where subsurface disposal by the foregoing methods is either undesirable due to groundwater pollution potential or infeasible due to certain geological or physical constraints of land. There is wide disagreement among researchers as to the limitations and capabilities of this form of disposal. For instance, there is agreement that ET beds are feasible in the arid regions of the western U.S. The disagreement relates primarily to the role of vegetation in the ET process. It has been shown by Bennett (1978) that the required area for an ET bed in Boulder, Colorado is 5,000 sq ft. This corresponds to an annual rate of ET on the order of 0.04 gpd/sq ft. The cost breakdown for a typical ET bed of this size is as follows:

| Item | Quantity | Unit Price (Installed) | Cost |
|---|---|---|---|
| Sand | 340 cu yd | $4.80/cu yd | $1,632 |
| Liner | 5,200 sq ft | 0.11/sq ft | 572 |
| Pipe | 625 ft | 0.50/ft | 312 |
| Gravel | 38 cu yd | 4.80/cu yd | 182 |
| Excavation | 375 cu yd | 0.76/cu yd | 285 |
| Hand labor | 8 man hr | 10.00/hr | 80 |
| Hauling | 370 cu yd | 2.00/cu yd | 740 |
| Grading, seeding | | | |
| Layout, supervision | | | 400 |
| Total | | | $4,203 |

Adding to this, the cost of septic tank and ancillary costs previously noted gives a total of about $5,000, or $1.00/sq ft. Reported costs from around the country have been between $0.75 and $1.60/sq ft. The above breakdown appears to be reasonable in light of these costs. The most obvious conclusion to be drawn from the above table is the amount of cost (40 percent of bed) accruing to the sand. As with the mound, a wide variance in the cost of sand would make a dramatic change in the cost of an ET bed. Unlike the mound, the restrictive sand size requirement for an ET bed (at least 50 percent less than 0.1 mm) may make availability and cost more senstitive to location.

The use of ET systems for summer homes eliminates the geographical barriers cited above. Since summer evaporation rates are generally higher and plants with high transpiration rates are in an active growing state, most areas of the country can utilize ET beds for this seasonal application. Also, research has been underway on developing mechanical evaporator units for more widespread use. Cost effectiveness of these units is being studied.

There are estimated to be 4,000 to 5,000 ET beds in operation in the U.S. Many are located in areas where pure ET beds cannot function at reasonable sizes without seasonal overflowing of their contents. When these systems do apparently perform without noticeable overflows, it is usually due to leaking liners. Most liners employed for these beds are less than 10 mil thickness. Given construction methods normally employed today, it would be highly unlikely if such a liner was not punctured or indeed perforated during the construction process. This system then performs both as an ET bed and as an absorption bed, commonly called an "ETA" system. Nearly 3/4 of all the ET beds that are in operation were designed to use both disposal methods, many of the rest do so despite the original intent of their designers. The cost of ETA systems would be essentially the same as an ET bed without its liner, some hand labor, and overhead, unless some known percolation value could be established which would permit a concomitant size reduction in overall dimensions. ET beds or ETA systems have no O/M requirement other than that associated with the septic tank.

## SURFACE DISCHARGE

Where permitted by code, surface discharge units can be employed in areas which may be otherwise unfeasible for individual home subsurface soil disposal systems. Because of the additional processing or treatment involved these systems are more expensive than conventional on-site systems.

Since septic tank effluent quality is clearly unacceptable for discharge to surface waters, additional processing is required which should be as consistent as possible with the principles of on-site treatment, i.e., simplicity and low O/M requirements. Filtration, with its positive removal mechanisms has traditionally been employed for this purpose. The three types of filters normally employed are:

1. Buried sand filters
2. Intermittent slow sand filters
3. Recirculating sand filters

Buried sand filters vary in their design, but a reasonably typical system is designed to process 0.75 to 1/5 gpd/sf through a vertical profile of 12 inches of gravel, 2 feet of sand (e.s. >0.4 mm), and 12 inches of gravel. The gravel layers contain the distribution and collection piping, and the entire unit is covered with a layer of soil. A typical cost breakdown for a 17 x 17 foot filter 25 feet from discharge and requiring a two foot layer of soil to give the depth necessary to operating a dosing siphon would be:

| Item | Quantity | Installed Unit Price | Cost |
|---|---|---|---|
| Excavation | 160 cu yd | $0.76/cu yd | $122 |
| Gravel | 22 cu yd | 4.80/cu yd | 106 |
| Sand | 22 cu yd | 4.80/cu yd | 106 |
| Filter pipe | 100 ft | 0.50/ft | 50 |
| Backfill | 25 cu yd | 0.50/cu yd | 12 |
| Hauling | 135 cu yd | 2.00/cu yd | 270 |
| Ancillary pipe | 25 ft | 2.00/ft | 50 |
| Grading, seeding, supervision | 1 | | 300 |
| Siphon | 1 | 500.00/ea | 500 |
| Total | | | $1,516 |

To the above would be added the septic tank and associated costs to yield a total of about $2,200. The above cost of the buried sand filter lies at the low end of reported costs of $1,500 to $3,000 for these units. However, because of their permanence and inaccessibility, many designers recommend dual-systems, which would result in costs in the upper range of the reported figures.

Another type of filter is the intermittent slow sand filter. Because of smaller sand size and higher loading rates (5 gpd/sf) these units require accessibility for periodic servicing. Where septic tanks precede these units two independent filters are required to allow for resting and recovery. Therefore, for a typical home, two 50 square foot filters and a pump dosing system are required, along with insulated removable covers. The table below represents a tentative breakdown of the costs of such a system wherein the sand depth is 30 inches, gravel 16 inches, and distance to discharge 25 feet:

| Item | Quantity | Installed Unit Price | Cost |
|---|---|---|---|
| Excavation | 40 cu yd | $0.76/cu yd | 30 |
| Tanks (1,500 gal) | 2 | 300.00 | 600 |
| Gravel | 5 cu yd | 4.80/cu yd | 24 |
| Filter pipe | 60 ft | 0.50/ft | 30 |
| Sand | 10 cu yd | 4.80/cu yd | 48 |
| tank mod., splash plates, insulated covers, etc. | 1 | 218.00 | 218 |
| Ancillary pipe | 25 | 2.00/ft | 50 |
| Grading, supervision, etc. | | 200.00 | 200 |
| Pump chamber | 1 | 800.00 | 800 |
| Total | | | $2,000 |

The above cost of the sand filter, without the pump chamber, is $12/sq ft which agrees well with Sauer and Boyle who have found costs to be $10-15/sq ft. The total cost of the system, including all other on-lot expenses, would be approximately $2,800, which also agrees with other field data which yield a range of $2,000 to $4,500. The most important note in the above table is the cost of the filter housing. In mild climates, it is possible that an excavated, plastic lined housing would suffice. The O/M requirements of these units are substantial and are associated with the pumping unit and periodic requirements for restoring sand filter hydraulic capacity. These costs may range from $100 to $150/year.

A relatively new type of on-site filter which has enjoyed success in Illinois and Oregon is the recirculating sand filter. In essence, the major components of this system are a recirculation tank (1000 gal) which contains a timer-controlled sump pump and a sand filter sized at 3 gpd/sq ft which contains three feet of coarse sand over one foot of gravel. Therefore, a typical system of this type located in a mild climate where filter covers are not required and 25 feet from discharge would be:

| Item | Quantity | Installed Unit Price | Cost |
|---|---|---|---|
| Excavation | 22 cu yd | $0.76/cu yd | $17 |
| Recirculating tank | 1 | 235.00 | 235 |
| Filter housing | 1 | 600.00 | 600 |
| Gravel | 4 cu yd | 4.80/cu yd | 19 |
| Sand | 12 cu yd | 4.80/cu yd | 58 |
| Internal piping | 100 ft | 0.50/ft | 50 |
| External piping | 25 ft | 2.00/ft | 50 |
| Miscellaneous | | | |
| Fittings | 1 | 50.00 | 50 |
| Pump and controls | 1 | 400.00 | 400 |
| Grading, supervision | | 200.00 | 200 |
| Total | | | $1,679 |

It can be noted again that the filter housing represents the largest single cost item for this system. O/M costs for these systems are mainly associated with the pump and occasional restoration of the filtering surface and is on the order of $50/yr. Adding the rest of the on-site components yields a capital cost of about $2,450 and an O/M cost of about $60/yr.

## DISINFECTION

When surface discharge systems are employed, as in the previous section, effluent disinfection may be required. With on-site systems, three likely disinfection systems are:

1. Tablet chlorination
2. Iodine crystals
3. Ultraviolet (UV) irradiation

### Chlorination

A dry chlorine feeder with hypochlorite tablets is one system that may be utilized for wastewater disinfection. These systems require no power and rely on gravity flow through the unit to dissolve the tablets. The design of the individual units and their costs vary from manufacturer to manufacturer. The World Water Resources, Inc., flow system for dissolving the chlorine tablets (excluding all piping and tankage) retails for $105 (Jan. 1975). Obviously, one needs to provide a certain amount of plumbing and a holding tank/contact chamber; the final cost for a chlorine system may rise to $300-800 depending upon the particular design. Sauer and Boyle evaluated a dry feed chlorinator with a ST-sand filter effluent and found the actual dosage to be in inverse function of flow rate with an average dosage of around 20 mg/l. Based on the rate of tablet uptake in their field studies, it would cost around $23/yr (chlorine tablets were $1.98/lb) to treat a 200 gpd flow. The maximum run length before the feed tubes need to be refilled in the Diamond Shamrock Chlorinator Model 200 is indicated by the manufacturer to be 3-4 months. Hence, in a community managed system it would be necessary to schedule maintenance/refills at this frequency.

Reported costs for tablet chlorination have varied from $150 to $1,200, but these data are not totally clear on what components have been included. Reported O/M costs vary between $20 and $50/yr.

### Iodination

According to Cook (1975), the price of an 8 lb iodination unit (including the iodine crystals) manufactured by Iodinanics is $267. The 5 lb unit costs $198. Crystals for replenishment cost $11.95 per lb. Owing to the limited solubility of the crystals, the Iodinator only needs crystal addition about once per year. Although actual requirements are not specified, approximately 3-5 lb/yr should be approximately correct.

In his evaluation of the disinfection of drinking water supplies, Cook (1975) found that the iodine residual was constant as long as any combination of pressure and flow was maintained. In field installation for wastewater effluents, the unit is normally used in conjunction with a pump to maintain flow and pressure across/thru the system. Pumping costs and holding tankage costs must be added to the basic unit costs above to determine the total installed cost.

No field costs for $I_2$ disinfection of on-site systems are available. Since they require pumping, it is reasonable to expect that the total system capital costs will be in the range of $600 to $1,000 and the O/M costs will be between $70 and $100 per year owing to the pump and iodine crystal replacement.

### Ultraviolet Irradiation

A UV water purifier was used by Sauer and Boyle on a ST-sand filter effluent. The unit was equipped with an automatic wiper and operated at 4 gpm with a detention time of 11 seconds. Power requirements for continuous lamp operation were 1.5 KWH/day, for intermittent operation 2.2 KWH/month.

The cost of a 3 gpm sterilizer manufactured by Aquafine Corporation is $395 (Feb. 1975). If units are equipped with automatic wipers and/or optional equipment such as indicator meters, optical sensors, etc., the price will easily double. Costs for pumping must be estimated separately.

Maintenance costs for cleaning and lamp replacement were estimated by Sauer and Boyle (1977) to be $45/yr.

A complete UV package, including pumping and UV units, could be expected to cost from $800 to $1,500 depending on climate and other local circumstances. The O/M costs would be expected to be between $80 and $130 per year for UV maintenance, pump, and UV power.

Taking representative values from the three disinfection systems cited above and the three sand filter types previously described yields the following matrix of costs:

| Disinfection | BSF | ISF | RSF |
|---|---|---|---|
| $Cl_2$ | \$2,800 | \$3,300 | \$2,950 |
| $I_2$ | 3,100 | 3,600 | 3,250 |
| UV | 3,300 | 3,800 | 3,450 |

A similar table for O/M costs follows:

| Disinfection | BSF | ISF | RSF |
|---|---|---|---|
| $Cl_2$ | \$45/yr | \$160/yr | \$95/yr |
| $I_2$ | 95 | 210 | 145 |
| UV | 105 | 230 | 165 |

## AEROBIC UNITS

Heretofore, all alternative systems discussed have employed septic tanks for preliminary treatment. In recent years there has been much written of the benefits of aerobic units in place of septic tanks. Since their introduction, sufficient data have been collected to show that these units:

1. Require regular O/M
2. Perform more consistently following septic tank or other pretreatment
3. Reduce soil clogging only in coarse (sandy) soils
4. Do not significantly affect evaporation rates
5. Offer their greatest potential for surface discharge application in concert with a polishing system

The following economic discussion is limited to aerobic units used in surface discharge arrangements.

Numerous field studies have shown that well-maintained aerobic units produce effluents containing concentrations of SS and BOD somewhat in excess of secondary treatment requirements (30:30). Therefore, some form of polishing treatment is necessary to attain the secondary standard. If a well-maintained, well-designed aerobic unit normally produces a 40:40 effluent (BOD:SS), a small filter of some type should make the effluent acceptable by the secondary treatment standard. In fact, Sauer and Boyle (1977) indicate that an ISF size may be halved when following an aerobic unit. Unfortunately, no data are available on simple configurations such as sand-filled trenches which are used in some Boyd County installations. Therefore, in order to establish any system cost information, formal designs such as the reduced ISF are used.

A typical aerobic unit is difficult to conceive, since designs are quite varied. For the purpose of developing costs, a unit design which involves pretreatment (settling) and a final pumping step (usually found in batch treatment units) has the advantages of more consistent operation, positive head availability, and dosing capability. Reported values from the field indicated that such a unit can be installed for \$300 to \$700 over the delivered price. Given a reported installed cost range of $1,000 to $3,500 the delivered price of these units would vary between $700 and $2,800. The type of unit described above could be expected to cost at least $1,800. Using these assumptions, a typical aerobic unit, completely installed with permit, design, etc., could be expected to cost about $2,600. The reported O/M costs for these units can be broken down into operation (power) and maintenance. Power requirements vary from 2 to 10 KWH/day and maintenance costs include regular visits (monthly to bimonthly), solids pumping (every 8-12 months) and repair of mechanical malfunctions. The reported costs from the literature for these maintenance requirements vary from $50 to $150 per year. Therefore, at an averaged power cost of 5¢/KWH, total O/M should run between $90 and $333 per year. Again relating to the "typical" unit described above, an annual O/M cost of $200 is assumed.

If the polishing process chosen for the aerobic unit is either the buried or recirculating sand filters previously described, it would be difficult to determine where cost savings might accrue when compared to septic tank effluent treatment. For the BSF unit, the recommendation for dual systems could be eliminated, but no data exists for these (BSF and RSF) units on which design decisions could be based. In the case of the ISF, data does indicate that the filter size could be halved. Also, since the unit assumed has a pumped effluent, the intermediate pumping chamber could be eliminated. Therefore, comparison of the aerobic unit (AU) and septic tank (ST) -ISF systems, results in the following:

| Parameter | ST-ISF | AU-ISF |
|---|---|---|
| Capital Cost | $2,800 | $3,400 |
| O/M Cost | $100-150/yr | $245-270/yr |

This more vividly restates the point made earlier that a simple, inexpensive polishing step combined with a reliable low-cost aerobic unit offers promise, but more structured and costly filtration systems which provide treatment "overkill" are not appropriate if cost-effectiveness is sought.

Although at least one state has encoded a 1/3 reduction in field size for aerobic systems (compared to septic tank systems), it is interesting to note that economics are still unfavorable in that a SAS capital cost savings of less than $500 would be offset by an AU capital cost increase of at least $225 and an O/M increase of at least $80/yr.

## WASTEWATER MANIPULATION

Flow reduction is probably the single most desirable action that can be performed by a homeowner with a properly designed and installed on-site system. Flow reduction alone should result in increased life of a functioning system and improved performance by a sluggish one. In the case of extremely expensive non-conventional on-site alternatives which are flow-sensitive, e.g., evaporation systems, surface-discharge filters, etc., the investment of relatively few dollars in flow reduction equipment will result in several hundred dollars reduction in capital cost. For example, a 25 percent waste flow reduction can cost less than $200 and save almost $1,000 in a reduced-size ET bed. Pollutant reduction through the use of non-water carriage fixtures offers not only waste volume reduction, but also pollutant reduction. The value of pollutant reduction to on-site wastewater system owners is a complex and sometimes argumentative subject. The types of fixtures normally employed to accomplish this reduction are waterless toilets or, possibly, very low flush toilets with holding tanks for periodic trucked disposal. Graywater processing can include normal on-site disposal or recycling methods.

Waterless toilets are available in many forms and designs at a wide variety of costs. For example, the following list of typical generic types with associated reported costs is shown below:

| Toilet Type | Installed Capital Cost | O/M Cost |
|---|---|---|
| Large Composting | $1,500-2,500 | $10-30/yr |
| Small Composting | 700-1,000 | 20-70 |
| Incinerator | 600-1,200 | 50-200 |
| Very Low Flush (air and water) | 500-600 | 20-50 |
| Low Flush Volume | 110-220 | - |
| Conventional | 100-200 | - |

Graywater recycle systems are presently marketed, but insufficient cost and reliability data do not permit quantitative economic analysis. Recycle systems can vary in initial cost from a few hundred dollars for home-made systems on up to several thousand for sophisticated commercial systems. Therefore, any proposed recycle system will require careful review of component functions, feasibility, probable performance and capital and operating costs. On-lot graywater systems could be expected to cost the same as conventional systems, less a 1/3 reduction in field size. Therefore, the following abbreviated list of on-site alternatives with their associated capital costs for total combined and graywater options is presented:

| Option | Combined | Graywater |
|---|---|---|
| ST-SAS | $2,275 (1000 sq ft) | $1,775 (667 sq ft) |
| ST-ET | 5,000 (5000 sq ft) | 3,600 (3,333 sq ft) |
| ST-ISF | 2,800 (100 sq ft) | 2,500 (67 sq ft) |

O/M costs would generally be reduced also, but exact figures are not available.

## ALTERNATIVE OVERVIEW

The above list of options and associated costs is presented with the purpose of making the reviewer of facility plans aware of some typical options, their experienced cost ranges and the cost sensitivities of these options, their experienced cost ranges and the cost sensitivities of these options to local conditions. Such information should provide the reviewer with the capability to quickly identify any unreasonable costs allocated to a particular alternative system or to verify legitimate cost estimates which differ from typical cost ranges by virtue of local conditions, e.g., the local cost of the key component.

It should be cautioned that although the above cost breakdowns are consistent with reported data, the data base for most of these alternatives is as yet insufficient to preclude change of relatively significant magnitude. Over the next few years, it is expected that a wealth of new information will increase the data base to a level of reliability which will permit these same analyses to be made with much greater confidence.

It is also cautioned that any reviewer understand that the analyses performed above are done for a limited number of alternatives and combinations of alternatives. Therefore, many combinations of the above unit processes and system substitutions are possible. However, by using the above information, some reasonable estimate of costs and performance should be possible.

Finally, the above information is based entirely on the cost of new facilities for the households to be served. In any realistic situation, there will be some amount of retrofitting of existing facilities. The cost of retrofitting will vary with the type and condition of existing facilities and the type of system to which they are being converted. In some cases, costs will be increased, e.g., retrofitting conventional plumbing to accommodate waterless toilets, and in other cases they will decrease, e.g., using existing septic tanks in a new STEP pressure sewer. The reviewer is advised to carefully determine these facts before determining the reasonableness of costs for various alternatives.

# "COSTS OF ALTERNATIVES"

Edited Questions and Answers Following Presentation
By Mr. James F. Kreissl
U.S. EPA-MERL Cincinnati, Ohio

(Mr. J. F. Kreissl gave his presentation on Costs of Alternatives.)

## Session 1

Audience: I noticed that you allowed $250 for the engineering of the system. We proposed that if a developer would spend $250 to $300, we thought we'd cut our failure rate by 90 percent. They're just not spending that much.

Mr. Kreissl: That's true. In fact, there's some very interesting work....I don't know if anyone is here from Vermont. But they have a district up there, the White River District, and they did a little study of systems in that district and their failure rates versus who designed them, who put them in, what soils, etc. Those systems that were designed by sanitarians on their staff and engineers had a rather equal failure rate which was pretty low. And then those that were put in by builders failed at many times that level. Interestingly enough, as a sidelight, they found that the failure rates for very marginal soils (tight soils which just make the limit as far as perc rate) was reasonably low in both cases. It was the in-between soils where they have all the problems.

Audience: A study in Connecticut showed that in one town in particular (this was several years ago) a majority of the failures were happening in the best soil. They basically attributed it to a deficiency in the code where they were allowing too high an application rate in sandy soil.

Mr. Kreissl: That's a good point. Another item along those lines has to do with the type of year in which they were installed. I guess Dick talked about the installation in wet conditions in tighter soils. The Hill and Frink studies in Connecticut showed that the....failure rate for the systems that were built in the wet years, was much higher than for those built in the dry years.

Audience: In Minnesota in some of the heavier soils some of our contractors have gone to putting breaker teeth on the side of the bucket in addition to the one on the front end of the bucket to keep from smearing off the sidewalls. It's worked extremely well.

Mr. Kreissl: It sounds like a good idea. I'm curious what is the difference in cost or what does that modification cost?

Audience: Most of them just take three-quarter inch bolts and weld them to a plate and just bolt the plate onto their bucket. They don't leave them on all the time because if they use the bucket for a basement or something, they want to smear off the sidewalls to have them stand up. But most of them have said the materials are like five bucks. And they did the labor themselves so that's hard to say.

Audience: Has there been any research done on trying to develop better varieties of vegetation to put over these ET beds? I can see how, as you mentioned, the effect of the cover influences the beds. Small shrubs--that would in a way hold back your actual evaporation rate just because of the shading effect. But it seems to me that that would open up a whole field of mechanical research. You could develop varieties of plants that would provide a certain amount of landscape value as well as increase the transpiration enough so that it would actually aid in the process.

Mr. Kreissl: Well, at Colorado we had a look at several types of vegetation. The juniper pfitzer was the only type which appeared to work pretty much year round. There's a great difficulty in water level. It goes from bone dry on up to almost the lip of the thing throughout a year's cycle. And this is very difficult for plants to grow under these conditions. The juniper pfitzer is, I believe, the one that Bernhardt recommends.

Audience: Your flow reduction brings up a good point. We've got one community that says they won't do it because they'll have to increase their water rates if they don't keep making money on the water supply. And it's not feasible for them, locally at the moment.

Mr. Kreissl: This is going to happen. If you go community-wide flow reduction, the water utilities have to do that. They're going to have to raise their rates because they are a utility. By definition, they've got to.

Audience: Then you've got the increased sewer use charges coming on there, too.

Mr. Kreissl: Not necessarily. We're not talking about sewer use here anyway. We're talking about non-sewer situations. They raise their rates which means that the homeowner, even though he's saving some water, is paying the same water bill. So he comes out dead even there. But in terms of the effects on his wastewater system, that's where his potential benefits lie. So even if they do raise rates, I don't think that abrogates the validity of it.

# "ALTERNATIVE COLLECTION SYSTEMS"

Edited Questions and Answers Following Presentation
By Mr. James F. Kreissl
U.S. EPA-MERL Cincinnati, Ohio

Session 2

Audience: Where do the odors generally occur?

Mr. Kreissl: Well, as Bill says, with the STEP System, the only place that you are probably going to get odors is going to be somewhere where the engineer didn't think and fired it into a manhole or somehow agitated it, in order to strip odors. With a grinder pump system, you have very strong wastes. You have, essentially, the low household waste with no dilution, and it is, essentially, in a septic condition, though not as septic, if you can go by degrees, as a septic tank waste. So, you would probably have some similar problems and maybe even a few that are unique to the grinder pump waste. But, my guess, again, would be where there was some violence in the system and the gases could emanate from it.

Audience: So you may not have the flow all the way through the system. If it is a small amount of flow, you may get enough to pull a couple of those and then it will sit there until somebody else flushes?

Mr. Kreissl: In actuality, you could have too little flow to actually form a plug and it could lay here in the bottom. So, once you have enough to, essentially, reach the top, to where you closed off and created a plug, then it goes. But, until then, the air will just pass over the top of it, going back to the station.

Audience: Jim, what if this had a hairline crack?

Mr. Kreissl: My favorite question. Thank you, Jerry, I don't know. Quite honestly, it would be a problem. If it were a hairline crack, it would probably just continue to run, because you have an inward flow. You are not losing any liquid that will show up anywhere. You are just sucking in some air. That type of failure would probably go undetected, unless they had a regular program of maintenance where they would check. It is recommended that you go around periodically to each vacuum valve and test the vacuum on it. In that process, they would determine that there is something wrong between two location if there was a crack. Then, the question is, is it worth it to go in, or just wait until it gets worse? I don't know. The hairline crack is a difficult one. I think it is just a loss in efficiency. The problems in systems that are in or have been in a few years, the big problem has been in the controller, which you saw with the valve. The controllers, when they have failed, they have caused some serious problems. The controller failure with the valve in the closed position always bothers the home that is served by that particular unit. Unfortunately, when it fails in the open position, it will drain vacuum from the system, and your whole system really goes dead, depending on the size of the system, or at least a good chunk of it will. Then, of course, there are alarms that go off, at the main station. And, if there is nobody at that or at the police station, or however they get ahold of people, then there is a set procedure for them to close off certain valves and watch the vacuum results to where they can identify which line it is on. And, in one location in Indiana, where there are about a hundred and fifty homes, it took them, I believe, about thirty minutes to find the valve that had been purposely failed by someone not associated with them in any way. In fact, it was our contractor. So, they can find that kind of a failure rather quickly, even though it is severe while it lasts.

Audience: Jim we have one system in the State of Washington that serves 25 or 30 people. It was designed for one station. We have an odor problem. We have yet to find out why. We had one odor problem with a lift station. We pump up through an absorption field and the sewer is dumped into this one main lift station. We had a terrific odor problem. Because of the agitation and everything churning up, the acids were coming off. We solved that by simply adding some more inlets into the lift station. We just dropped the pipe down below the water surface and eliminated the odor all together. That is the only source or a report we have.

Mr. Kreissl: Well, that is a repetition of the pressure sewer experience. If you are dealing with septic tank effluent, you don't want to agitate it, unless it is absolutely necessary, because by nature, it doesn't smell, until you do something to it.

Audience: One problem you could get with combining the systems, is the people that don't have to put in the pumps and have the extra power possible, would be quite happy, but the group that ends up having a pump in their yard, it is like, why in the world do I have to pay more than the guy down the block?

Mr. Kreissl: Absolutely true. Well, you are talking about the same problem that Bill was discussing this morning. It is something that you could really toy with, in your mind. There are sociological studies which indicate that if there are two or three people on the same unit, you are going to turn friends into enemies. You know, there is a very high sociological problem here.

Audience: Like Jerry said, it is like going sailing with the same family for four years.

Mr. Kreissl: Exactly. When it gets to four or more, these studies indicate that the people start to perceive of it as a community system. And, the animosity goes way down. I am sure these numbers aren't hard, but the curve is probably realistic. But, the question is, if you could have a separate line with several homes being served? You could have a separate line which, essentially, becomes a municipal type charge, which they pay and charge back in taxes equally for everybody. There are a lot of arrangements that one can fool with. But, I will tell you in terms of technical, in the Bend, Oregon Project, we had some ones, some twos and threes on a single pressure unit, and absolutely no problem at all, technically. So, I mean, you really don't have to think about going to duplex units and things like that. The single units seem to do very well, throughout the period, which was in excess of a year.

# EPA CLEARINGHOUSE FOR SMALL WASTEWATER FLOWS
# PRESENTATION OF PROGRESS

by

Mr. John Brewer

Enviro-Control, Inc.

## INTRODUCTION

The establishment of a clearinghouse for dissemination of information on small wastewater flows was suggested in a national conference on wastewater treatment systems for small communities in April 1977. It was written into the Clean Water Act of 1977. In 1978 a contract was jointly funded by EPA's Environmental Research Information Center (ERIC Cincinnati) and the Municipal Environmental Research Laboratory (MERL Cincinnati), to Enviro Control, Inc. to set up the necessary computer information indexing system and all pertinent reference material.

In August of 1978 progress on the project was reported in the conference on "Wastewater Alternatives for Small Communities" by Mr. Brewer of Enviro-Control. The clearinghouse talk was an informative introduction on the possible use of such a clearinghouse which culminated in a discussion period. The discussion is reported in this conference proceedings publication.

The clearinghouse in 1980 is now a reality and is based in Morgantown, West Virginia at the West Virginia University. A 1979 Bibliography of Small Wastewater Flows was compiled by the professional staff of the clearinghouse and is available for a small fee. A toll free number can be used for information about the clearinghouse. The number is 800-624-8301 and the address is West Virginia University, Morgantown, WV, 26506.

Introduction prepared by

S. W. Hathaway

# "SMALL FLOWS CLEARINGHOUSE"

Edited Questions and Answers Following Presentation
by Mr. John Brewer
Enviro Control, Inc., Rockville, MD

AUDIENCE: I'm a little concerned about this initial screening that you're going to be doing. Who's going to do it, and do they know anything at all about on-site systems? I've discovered there's an awful lot of literature out there. If somebody who's not familiar with it picks it up and says, "Oh, my gosh, this is really great stuff," and starts disseminating it, you're going to be doing more harm than good. I'm just wondering who you're going to get to review this or if you're going to do it yourself.

MR. BREWER: I am not going to do it myself. We have Jerry here and Dick Tucker. But the purpose of the criteria is to develop a set of guidelines by which this screening can be done. And secondly, once the data has been initially screened and the initial bibliography has been prepared, we'll submit this to Dennis for refereeing and he will identify several people within EPA and perhaps within ERIC who will referee the bibliography and decide that yes, these are appropriate or no, they are not. So the initial screening that we do will be very elementary.

AUDIENCE: I'm also concerned about the secondary screening then because do these people....I mean I'm sure they know how to screen data and how to do bibliographies. But if they don't know on-site systems or alternative collection systems, it's going to be very difficult. They're going to have to spend a year getting trained before they can do it.

MR. BREWER: Absolutely. And that's the purpose of having the bibliography refereed by people within ERIC and within the Technology Transfer group. For instance, I suspect that Jim Kreissl will be one of the people who will be looking at it.

AUDIENCE: Would your Clearinghous provide change of, say, each state's regulations? Say, we would like to have access to the State of California's septic tank regulations.

MR. BREWER: The intent is to have the regulations by state. You should be able to index into the listing of regulations and guidelines by state. As I say, one of the things that we're interested in getting here is any recommendations about methods of collecting this data initially and any suggestions about how we might monitor the changes of this because we do want to keep it updated as changes in legislation affect various regulations by state. We would like to be able to acquire that at the time and update the list of regulations.

AUDIENCE: That was may second question. how will you keep up the list?

MR. BREWER: I can't answer your questions right now. I'm trying to find that out.

AUDIENCE There's a good start on that. Gary Plews from Washington State, the State of Washington Department of Health, has been maintaining a list of state regulations and has copies of a lot of them. Every once in a while he presents a paper and he's got a few more in the column. So he's got a good start on it.

AUDIENCE: Do you have any plans to include, I guess, general laymen "Joe Toiletflusher" or whatever, the guy that's out in the field that's going to be served by one of these alternatives and wants to know something about it? Will they be able to write in and get some of the information?

MR. BREWER: Well, that is a question which will have to be answered because to serve the general public requires a higher level of funding than, say, to serve just the professionals in the field. We will make recommendations about that. I understand that there are a number of questions that occur now. Perhaps Senator Randolph's committee handles a lot of those. So perhaps it is a necessary function or service to be provided by the Clearinghouse -- that there should be that central point for the general public.

AUDIENCE: There probably won't be anything constructive for a year from October coming back to us?

MR. BREWER: No. I would say that the initial products which we are developing will be available very soon, probably in November.

MR. J. F. KREISSL: I think it would be sometime next year because the budgeting for our '79 program is really not complete. John has really done the basic work. Someone would have to pick it up and actually be the Clearinghouse with new money that we haven't gotten. So you are looking at '79.

AUDIENCE: Somebody mentioned about the plan. That leads me to think that some of you know that there is a newspaper type of sludge and you can mail your information to the laboratory. I wonder if this kind of newsletter can be used until your Clearinghouse would be in operation on a full scale. If funding is a problem at the federal level, perhaps maybe some state if they want to.....apply for a grant and EPA would be gracious enough to give the grant so they can start a newsletter on a small scale.

MR. KREISSL: That's one of the serious possibilities that we have to consider, the interim arrangement. If I understand you, that's what you're saying. There's something existing that's good. In fact, from the very beginning we've talked about that concept. These are the kinds of things that Don and his group are also contemplating. How would we function on an interim basis? You know, until we develop our own newsletter, is there a newsletter out there that is good that can be used? Or until we develop some type of document on on-site sytem management, let's say, or technology, is there a document now that's the best to serve in the interim to provide when people send in and ask for such a thing? And these are the kinds of decisions the Clearinghouse has to make. That's a good point.

AUDIENCE: But you said, if I remember correctly, you're going to wait, find out what these people need, what kind of information they need to develop the taxonomy classification. The trouble is if you don't have a good taxonomic classification in the beginning, the people aren't going to be able to get the information out in the first place. It's like which came first, the chicken or the egg?

MR: BREWER: Well, what we have is a two-stage process. One, we have a lot of people in the field already developing data bases, as you mentioned, the Enviro-Line, or various other online data bases; and each data base supplier has his own indexing scheme, and it varies from supplier to supplier, so our job there is to develop a search strategy that will retrieve all of the pertinent data across all of those data bases. Secondly, then, our job is to define a taxonomy which is useful to people in the field and then the Clearinghouse makes the mapping between the two, such that, by the time the Clearinghouse gets through, you should be able to get the information you need relating to a taxonomy that is relevant to you, without having to worry about the fact that one supplier does it one way and another supplier does something else and there's no cross-reference between them. So we're really in a two-stage process.

AUDIENCE: See, the mistakes are already out in the field. You don't have to redo the mistakes, we've already got that as a perfect example, a half a dozen of these search type of bibliographies that are already being placed. I hate to see you go ahead and do another bibliography based on another taxonomic basis that may be just as complicated as the ones that these gentlemen or these people have already done. That's what I'm worried about, is this going to be the eighth system that already exists. You don't have some sort of logical development of where did these people go wrong, I'm not sure I heard that today....I heard a lot of buzz words, but I'm not sure I heard any implementation facts. This is what I am looking for in something like this. What is the methodology which you plan to do to avoid these passing states?

MR. BREWER: The methodology for developing search strategy is what you're asking for, and that basically is to come in and do a very broad search and find all the documents that are relevant out of that broad search, and then, look at the documents which are not relevant to find out why....what it is about them, what the trends are that cause those to be hits. Secondly, then we narrow the search down and then begin to see which documents to not occur because of the terms that we have eliminated. And, in this way, we begin to bracket on what the proper search strategy is for this. And certainly, as we are doing this, the key words that we use for this retrieval become input into the taxonomic structure. However, I do think it is important that the structure be relevant to this particular user aduience. So I think it's important also that we have user input in the taxonomy so that it is a useful and easy to use indexing scheme, classification scheme.

AUDIENCE: The group you left out was the user -- you mentioned consultants, government people and the public. It looks like you just about covered everyone. The legislators and everyone else, and I don't see how you define users at all. I'm not saying there is anything wrong, I don't see how you've defined users.

MR. BREWER: Well, in the case of developing the taxonomy, obviously, the users are going to turn out to be the professionals in the field. The general public is down there as it being a group of people who may end up receiving information from the Clearinghouse. But that's more or less a one-way activity in that case, as just a dissemination of information. Primarily, the users of the Clearinghouse will be the professionals engaged in planning for engineering or research or design, that kind of activity.

# GENERATING AND ANALYZING ALTERNATIVES

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Cambridge, MA 02138

## 1.0 OVERVIEW

An orderly procedure for the inclusion of alternative wastewater treatment strategies into the facilities planning process can help achieve water quality objectives at reasonable cost in rural and urbanizing areas. In many instances, the crucial question is where and when (and how) to sewer. The extremely high cost of conventional gravity collections systems in relatively low density areas makes careful consideration of the sewering issue essential. In the past, centralized treatment and collection by gravity sewers were considered the ultimate objective of municipal wastewater management. The process of alternative generation centered primarily on the examination of the various treatment processes at the end of the pipe. While the extent of the sewers was sometimes an issue, the decision to sewer has tradationally been considered a foregone conclusion.

The objective of this project is to develop a methodology which extends the scope of the alternative evaluation process to the questions of whether or not to sewer by conventional methods. Alternatives which minimize the use of collection systems and maximize the use of both standard and unconventional on-site systems will be generated along with those utilizing conventional and alternate sewage collection and treatment technologies.

A considerable effort has been made to insure that the proposed methodology is both straightforward and comprehensive. A sequential approach is employed in which structural and nonstructural alternatives are evaluated, based on both quantifiable and nonquantifiable impacts.

The methodology is based on several axioms, which provide a starting point for the evaluation process.

- All proposed facilities and management plans must meet water quality and public health objectives;

- All programs should maximize the use of existing infra structure (sewers, treatment plants, septic tanks, etc.) where appropriate to minimize new capital expenditures;
- Land use controls should be considered as an integral part of the planning process, since they could potentially provide attractive alternatives to structural options, particularly for new development;
- All wastewater management facilities, whether on- or off-site, publically or privately owned, must be properly managed.

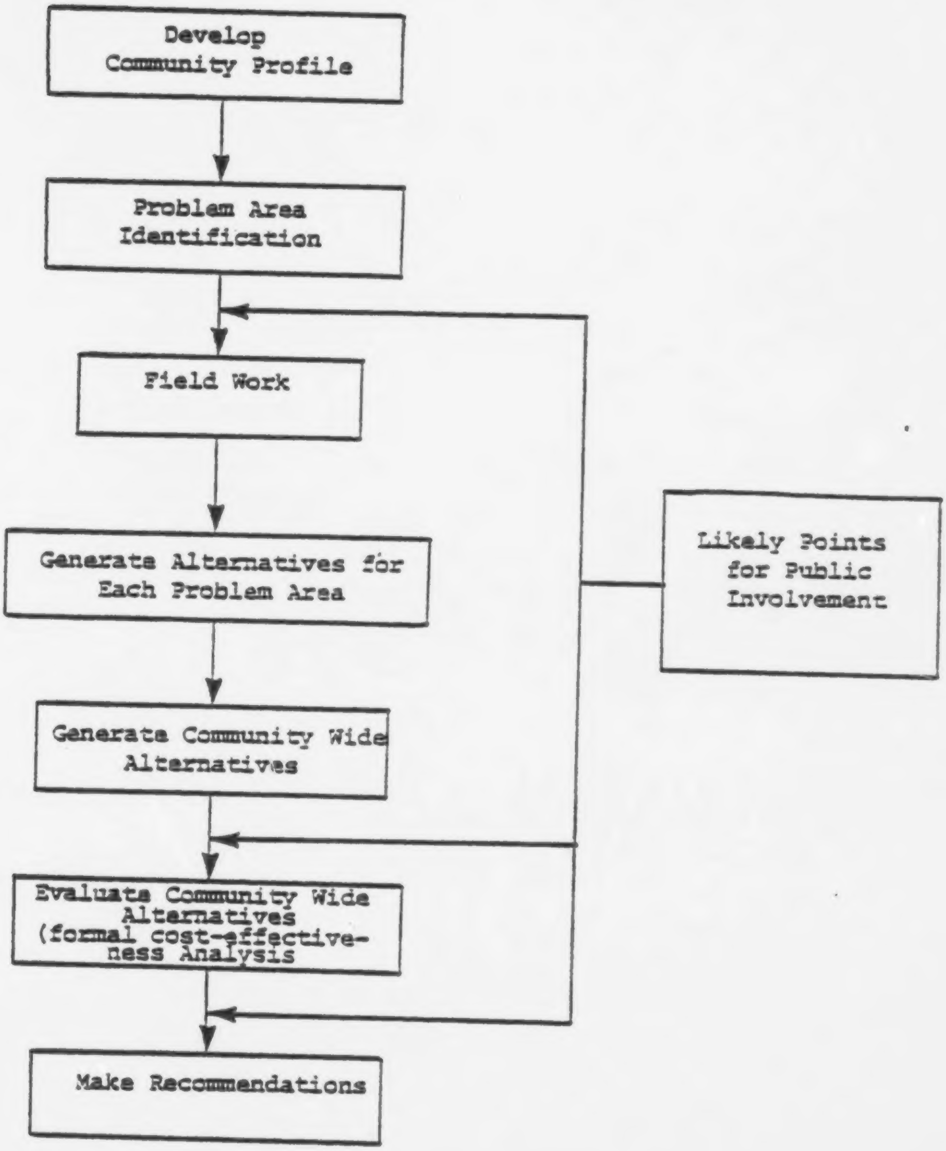
This methodology is designed to develop an appropriate wastewater management strategy for each member of the community. Thus, the recommended alternative may involve a combination of several different technologies serving areas with different needs. In many cases, part of the community will be served by traditional septic tanks with leaching systems. Other parts of the community may have collection of wastes for centralized treatment and/or disposal. The important point is that the overall solution should be made up of components which represent the best technological solution for the particular problems experienced.

A sequential methodology is recommended to achieve these goals. Exhibit 1.1 outlines the various steps in the proposed process. The approach stresses the need for original data generation through field work and more detailed study to identify actual problem areas and predict where on-site systems may not work.

The hypothetical community shown in Exhibit 1.2 will be used to graphically illustrate the various steps in the proposed methodology. This community borders on a river and includes a tributary stream. The older part of the community is served by on-site systems, many of which are failing. There is a portion of a state park in the community as well as municipal parks and conservation land.

EXHIBIT 1.1

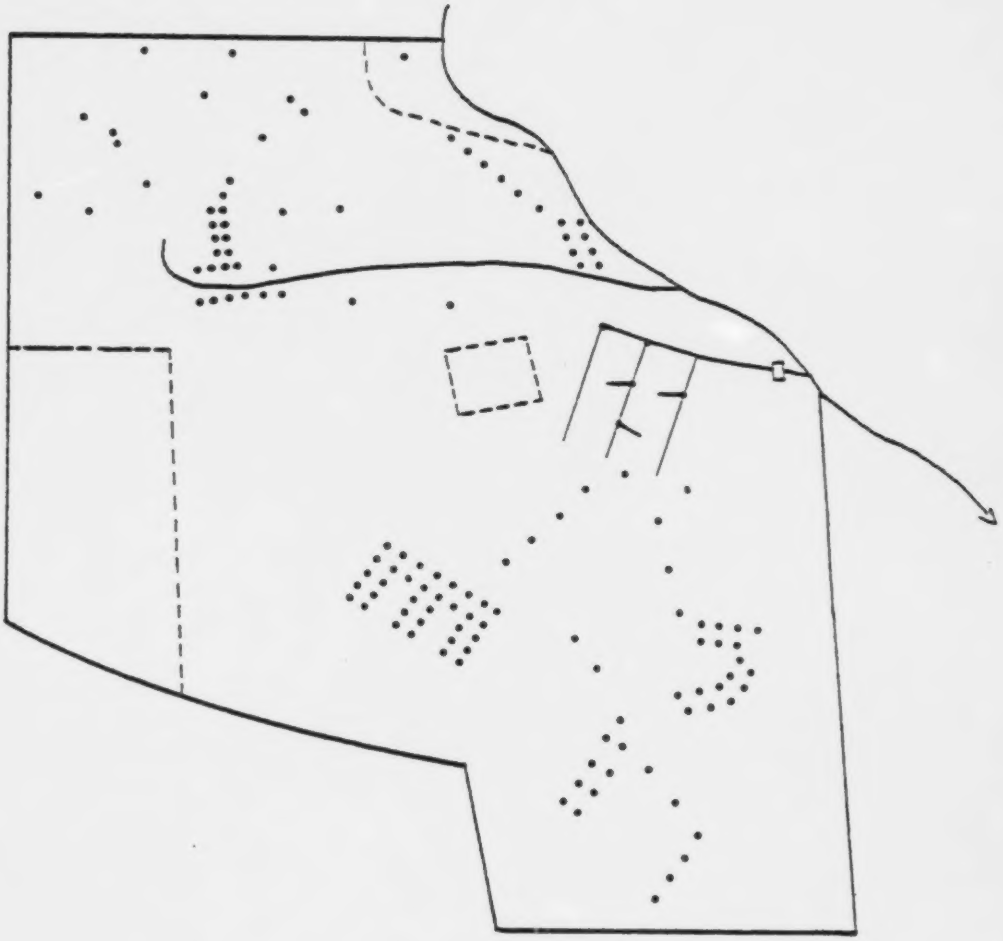
## STEPS IN THE SEQUENTIAL PLANNING PROCESS


Develop Community Profile
Problem Area Identification
Field Work
Generate Alternatives for Each Problem Area
Generate Community Wide Alternatives
Evaluate Community Wide Alternatives (formal cost-effectiveness Analysis
Make Recommendations
Likely Points for Public Involvement

## EXHIBIT 1.2

## COMMUNITY PROFILE

## MAP OF EXISTING SERVICE



- On-Site Conventional Systems

⁝ Sewered Areas

⬚ Institutionally Undevelopable (i.e., state parks, conservation land, etc.)

While the steps of the methodology are described in more detail in the remainder of the report, it is useful to describe them very briefly here. The community profile step collects secondary source data on items such as population and growth rate, existing service types (and, perhaps, failures), tax rates, land use, and water quality. One of the results of this step might be a descriptive map such as Exhibit 1.2.

In the problem area identification step, the community is divided into areas with or without existing (or likely) problems, with the field work used to refine these determinations. Problem areas are defined as those developed areas where existing technologies are not satisfactory and those undeveloped, but developable, areas where problems are anticipated. To make the second type of problem areas easier to define, we are assuming that future problem areas are those where standard on-site systems are not expected to perform satisfactorily, given the present land use controls and sanitary codes. Standard on-site systems will be defined as those which are currently allowed under state and local codes, with this list varying from site to site. For example, Exhibit 1.3 shows the hypothetical community after the collection and analysis of secondary source data, with a large area which may have significant problems. An example here would be a site with few apparent on-site failures, but soils known to have low permeability: some field checking would be done to see whether there were actual, unreported failures or whether the systems were, in fact, operating correctly. Exhibit 1.4 shows the community classification after field work.

The next step is to generate alternatives for the individual problem areas, such as those shown in Exhibit 1.5. Then, these alternatives are combined into community-wide systems, such as those shown in Exhibits 1.6 and 1.7. The overall cost-effectiveness and environmental evaluations should be performed on the community-wide systems, and a recommended plan chosen.

## EXHIBIT 1.3

## PRELIMINARY PROBLEM AREAS

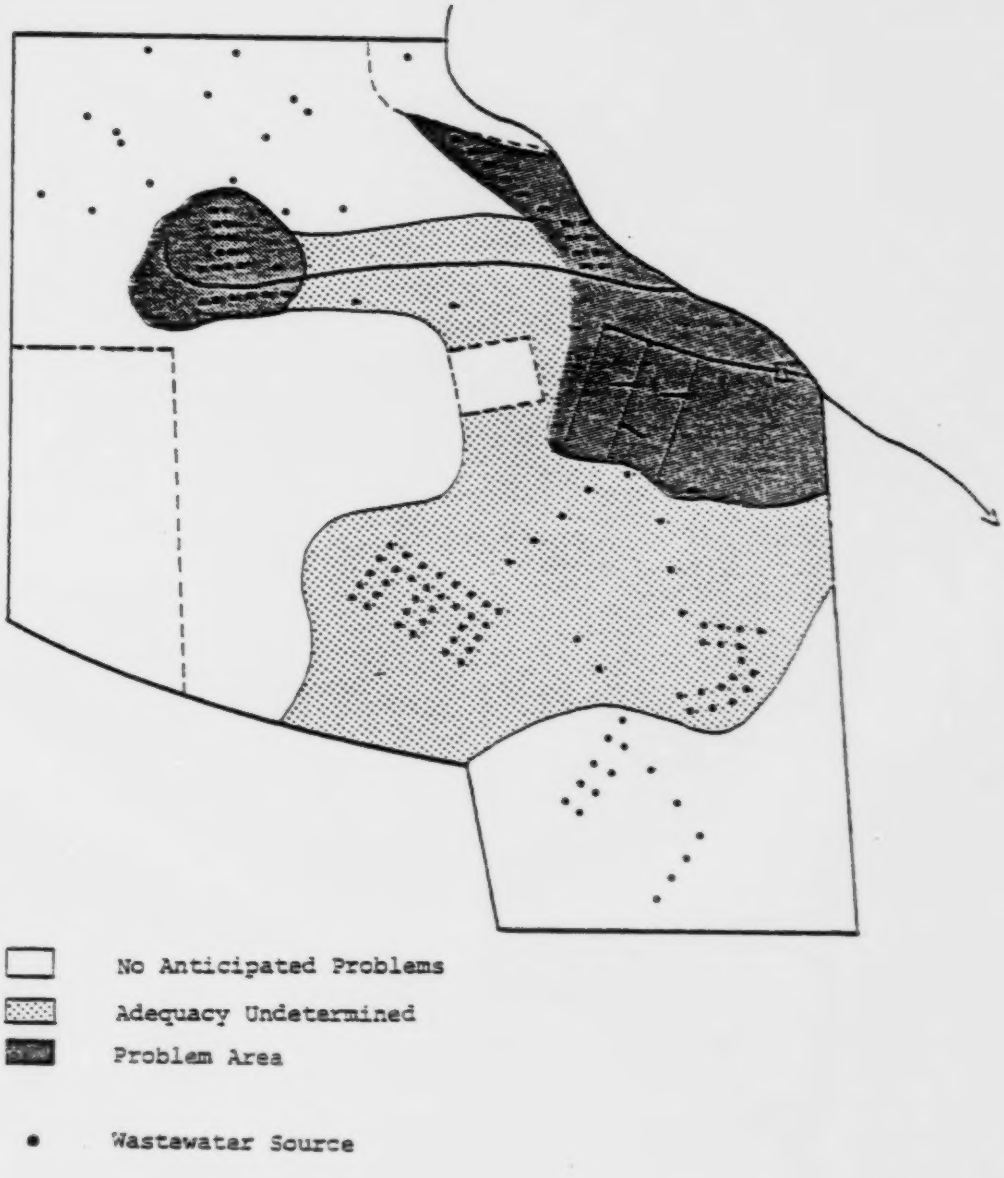
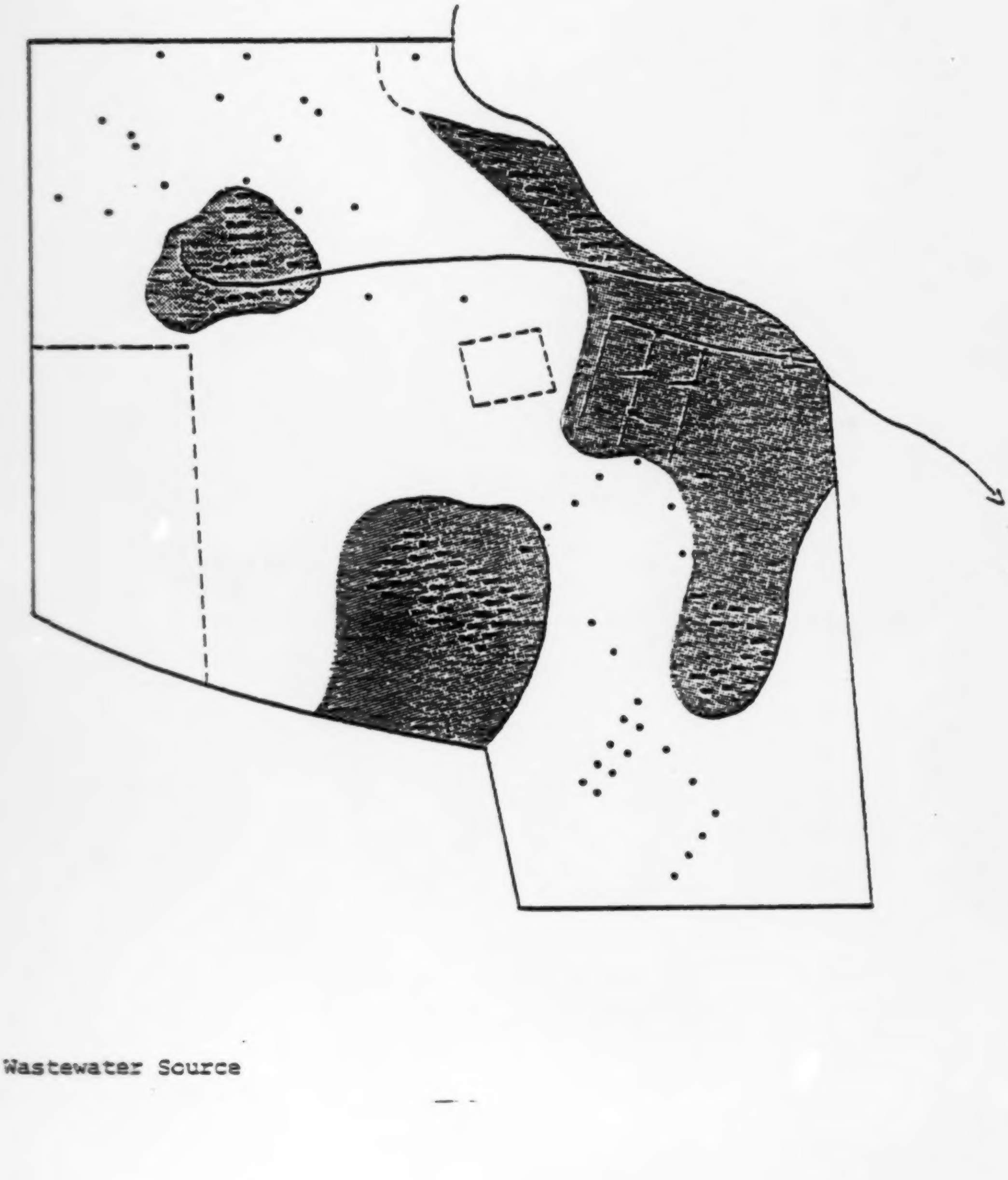

☐ No Anticipated Problems
▨ Adequacy Undetermined
■ Problem Area
● Wastewater Source

EXHIBIT 1.4

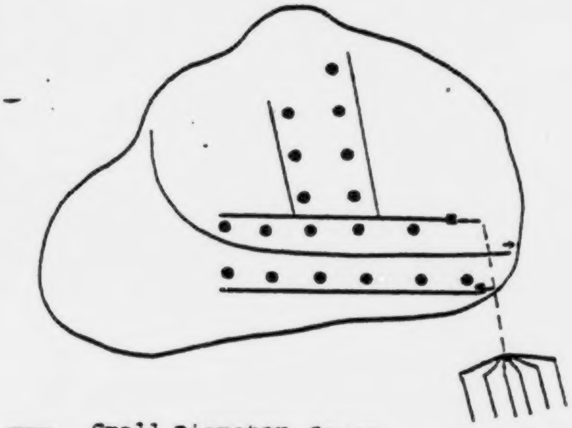
## PROBLEM AREAS
(after field work)



● Wastewater Source

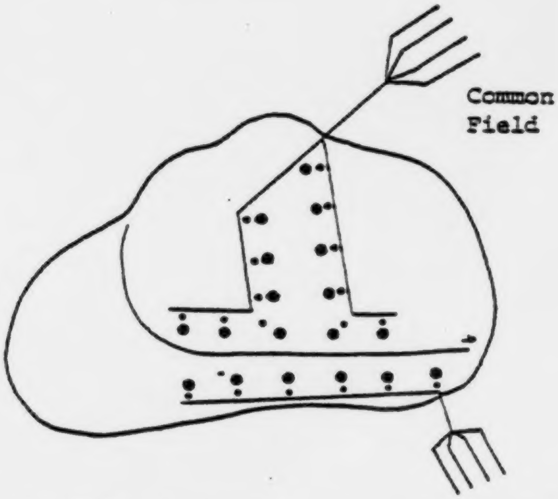
# EXHIBIT 1.5

## GENERATION OF ALTERNATIVES FOR EACH PROBLEM AREA


Common
Field

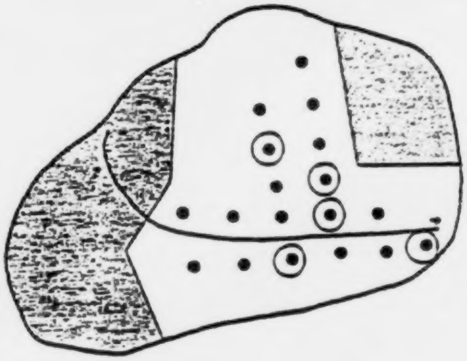
— Small Diameter Sewer

--- Force main


Common
Field
Common
Field

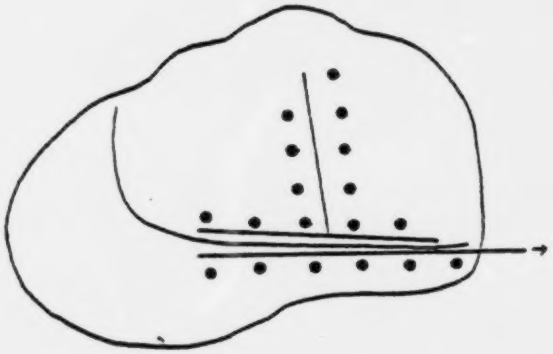
— STEP Pressure Sewers

• Individual Effluent Pumps



▨ Rezone to 1 unit per 80,000 sq. ft.

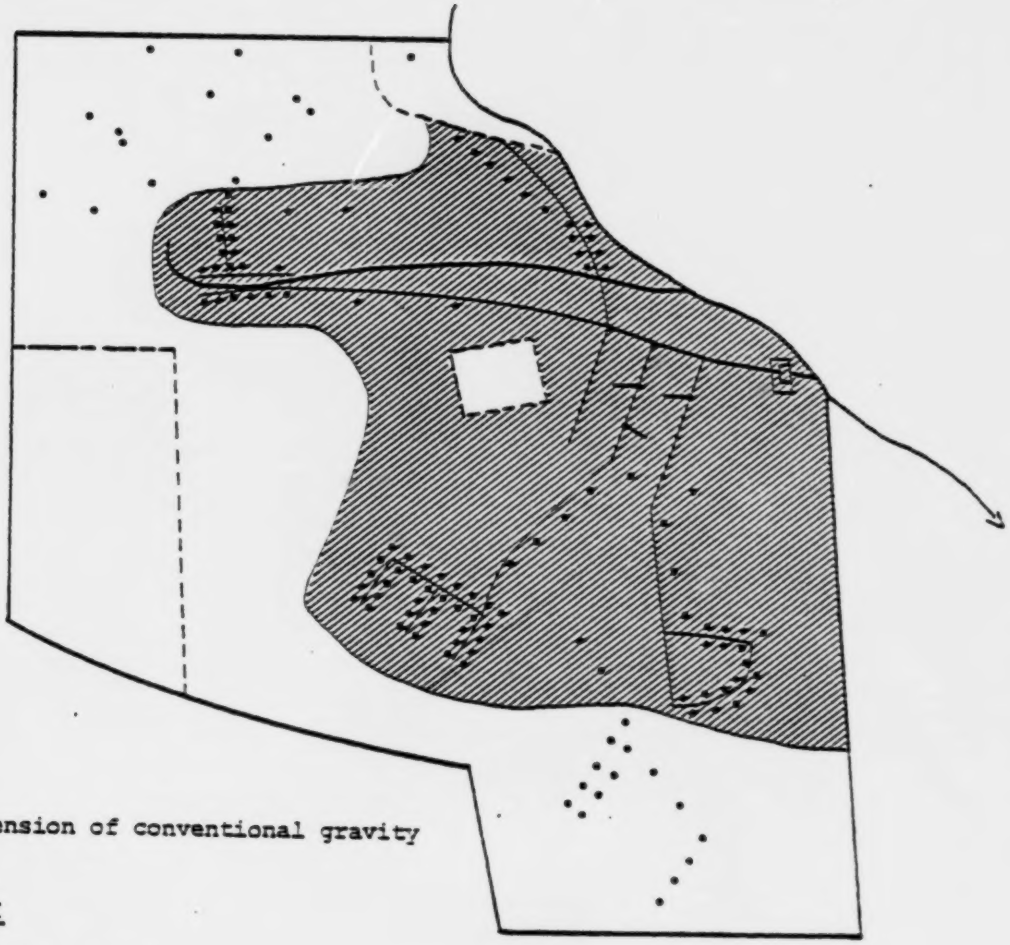
⊙ Rehab systems with serious problems install alternating fields



Conventional gravity sewers connected to centralized plant

## EXHIBIT 1.6

## SEWERED ALTERNATIVE



Maximum extension of conventional gravity sewers

Alternative I

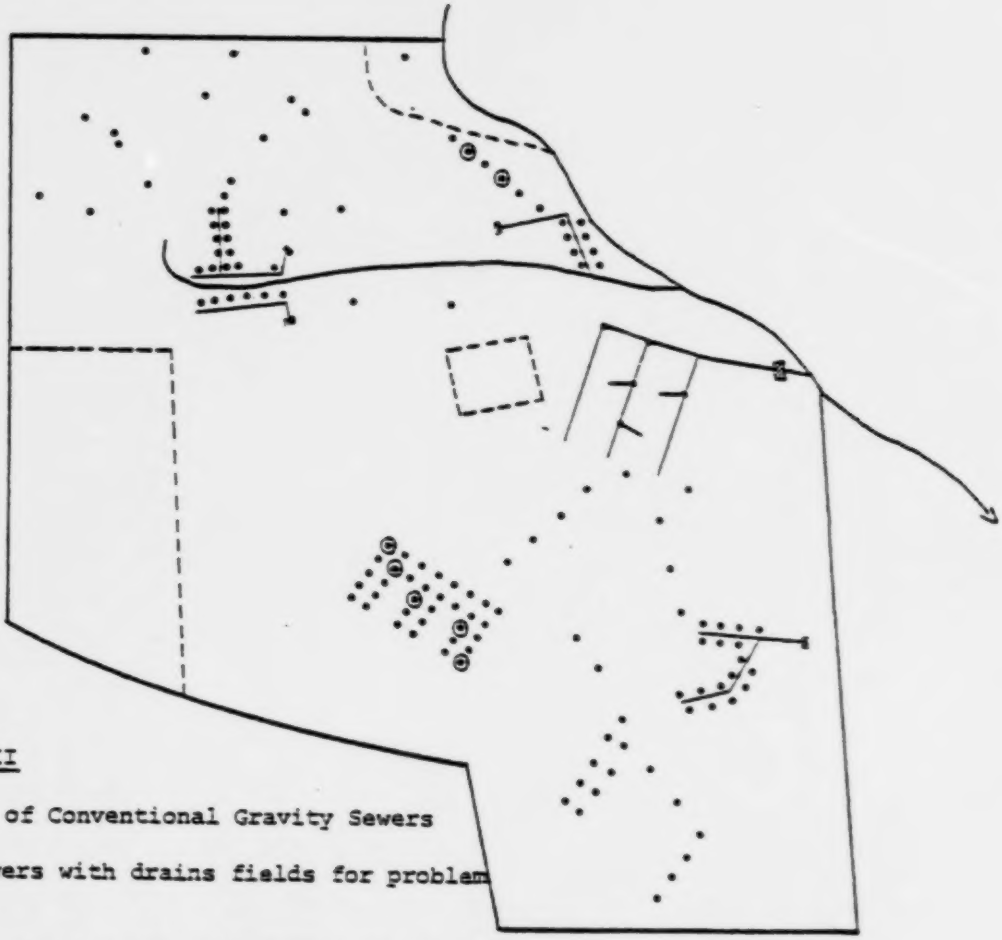
Upgrade and expand plant

▨ Potential sewer service area

● Wastewater Source

# EXHIBIT 1.7

## SMALL SCALE ALTERNATIVE



Alternative II

No Extension of Conventional Gravity Sewers

Community Sewers with drains fields for problem areas

Rehab of some on-site (o) maintenance of all on-site

Upgrade plant and increase septage handling capacity

The following chapters describe the individual steps in the process, as follows:

- Community Profile (Chapter 2);
- Problem Identification (Chapter 3);
- Field Work (Chapter 4);
- Generation of Alternatives for Individual Problem Areas (Chapter 5);
- Generation of Community-wide Alternatives (Chapter 6);
- Evaluation and Review Issues: Cost-effectiveness, community preferences, and public participation (Chapter 7)

## 2.0 COMMUNITY PROFILE

The purpose of the community profile step is to provide information useful later on in the actual analysis. In the later stages of the facility planning process, it will be necessary to have data on existing wastewater systems and their adequacy, on the powers and operations of the wastewater agency (and its finances), on the natural features of the site and regulatory limits, and on a host of other topics.

We have assumed that data which can be collected from secondary sources will, in general, be less expensive than new data collection. Therefore, we recommend a community profile step in which the engineer gathers data on topics ranging from population growth to groundwater quality, and from sources ranging from USGS to state agencies or even local well-drillers. An initial attempt to find the sources of information, and to bring together an overall picture of the economic, demographic, physical, and institutional aspects of the site will, in general, provide much of the information needed in the later steps. It will clarify what sorts of field work are required, and speed up the analysis process since much of the information will already have been gathered.

Judgment should, of course, be used extensively. The lists provided here are suggested types and sources of data, and certain items will or will not be available in particular situations. For example, land use information was unavailable in one case study site, but aerial photos were found, and these provided sufficient current information for planning. If you assume, however, that any data unavailable from secondary sources is likely to be collected through field work, it is clear that the useful data should be collected early, and this is the rationale for the community profile step.

There are four major categories of data about the community which may be important:

- Growth and Development
- Natural and Physical Features
- Existing Wastewater Disposal
- Existing Regulations and Institutions

These individual profiles are considered in the following sections, and suggested data sources are presented in the Appendix.

## 2.1 GROWTH AND DEVELOPMENT

Information collected in this category is essential in determining existing and future wastewater management needs. In addition, this profile will provide data on the potential growth and development impacts associated with wastewater management strategies. Exhibit 2.1 summarizes the data described below.

### 2.1.1 Population and Economic Base

This information will provide a profile of the demographic and economic trends in the community and will be important in determining existing and future wastewater flows and socioeconomic impacts. In accordance with the proposed wastewater grant regulations (40 CFR 35) for the 1977 Clean Water Act, the facilities planner should determine if the state or the appropriate 208 agency projections for the community should be used if available.

It is also important at this stage to generate basic data about the community's employment base. Is the community a declining industrial community? Are small water-using types of business, such as retail and service-oriented firms, the predominant growth type for the community? Such information will enable the planner to have a better understanding of the community's overall growth pattern. Finally, basic fiscal information about the community will be useful.

### 2.1.2 Land Use

Land use information is needed in order to determine waste-

## EXHIBIT 2.1

## GROWTH AND DEVELOPMENT DATA

### ECONOMIC/DEMOGRAPHIC

- population and population forecasts
- detailed employment data and forecasts
- local fiscal information (tax rate, etc.)

### LAND USE

- maps of current areas by type

### HOUSING

- household size
- community assessed value
- building permit trends
- zoning and sub-division regulations (and maps)

### OTHER

- current and potential historic register sites, and areas of archaeological significance water management needs and in order to identify potential growth impacts. The dilemma faced by the facilities planner revolves around the amount of land use information needed and the amount of effort that should be expended to collect it. There is no firm formula that can be universally applied.

At a minimum, for the Community Profile stage, the analyst should determine the overall patterns of existing development and expected growth in the planning area, including the areas that are likely and unlikely to be developed. Thus, public and semi-public land should be determined and mapped.

The scale and level of detail to which the analyst will map this information will depend on the existing pattern of development, the size of the planning area, and the availability of existing land use information. Sources of land use maps and land use information include the following:

Local: Planning Board, Building Inspector; Tax Assessor

Regional: Regional Planning Agency, 208 Agency

State: State Planning, Community Planning, and Transportation Agencies, Extension Services

Federal: Soil Conservation Service, U.S.G.S., and Land Management agencies such as the Corps of Engineers and the Forest Service

Whatever the source of the land use map, it is highly probable that it will need some form of updating. The following relatively low-cost methods are suggested as means for updating land use information.

- Interview the local building inspector to determine location and type of new development

  Technique: Request building inspector to draw boundaries of new development, noting type of new development (residential, commercial, industrial, etc.) density and changes in use.

  Level of Detail: Variable, depending on map scale, accuracy of additions.

## EXHIBIT 2.2

## SUGGESTED LAND USE MAPPING CATEGORIES

- **Residential:**
  - (1) Low density (<1.0 dwelling units/acre)
  - (2) Medium density (1-4 dwelling units/acre)
  - (3) High density (>4 dwelling units/acre)

  These may be altered to densities common to the locality.
- Commercial
- Industrial:
  - (1) Warehousing
  - (2) Manufacturing
  - (3) Extractive Industry)
- Publicly-owned Lands:
  - (1) Developed (recreation, municipal buildings, hospitals, schools, etc.)
  - (2) Recreation/Conservation
  - (3) Highway Rights-of-way
- Semi-public:
  - (1) Developed (churches, VFW, hospitals, etc.)
  - (2) Recreation/Conservation
  - (3) Utility Easements
- Agriculture (active)
- Vacant

Cost: Minimal, basically includes staff time for interview, redraw of added developed areas.

- Windshield survey conducted by consultant/planning office staff

  Technique: On-site, field inspection of newly-developed areas. Requires back-up information on recent development in the form of building permit. Can be used to locate newly-developed parcels or to identify new uses. The field sheet used to record this information can be tax assessor maps which will enable acreage to be determined.

  Level of Detail: Good.

  Cost: Moderate, basically includes staff time for survey, map corrections at office.

- Recent aerial photos to identify extent of recently developed areas.

  Technique: Purchase of aerial photos from public agency or private mapping company. Developed areas and densities can be delineated from aerials; uses must be checked through other sources (either of the above).

  Level of Detail: Depends on source of aerials. Enlargements can be made if negatives are available.

  Cost: Approximately $5/sheet, plus cost of mapping new areas.

Land Use Controls: An examination of the local zoning map and regulations will assist in determining conflicts between future development and natural resource constraints. Areas where wastewater management needs may occur under present zoning requirements can then be determined.

The existing zoning regulations may not be the only land use controls operative in the zoning area. The analyst should also check the local subdivision regulations, if they exist, and any specific state or local controls exercised in proposed land development (e.g., areas of regional concern, etc.).

Historic and archaeological resources represent limited and non-renewable districts, buildings, sites, structures, and objects having significant associations with historic, architectural, archaeological, or cultural events, persons, groups, and social or artistic movements. The project team, under EPA procedure,* has responsibility for identifying resources in the intial phase of the facilities planning process. At a minimum, in the Community Profile Stage, then, the project planner should determine the existing National Register sites. The State Historic Preservation Officer will also provide at this time guidance regarding other potential National Register sites.

## 2.2 NATURAL AND PHYSICAL FEATURES

Data requirements and possible data sources for developing a Natural and Physical Features Profile are tabulated in Exhibit 2.3.

Climate information is most useful to the facilities planner in terms of the constraints that it poses for certain technical alternatives.

Topographic information as provided on the U.S.G.S. Quadrangle maps is probably sufficient at the Community Profile stage to determine drainage basins; severe slope areas; and areas with significant undulating terrain.

At the community profile stage, a generalized soils map is useful for determining the potential suitability of land application and soil absorption systems. Where available, soil maps and accompanying interpretative reports developed by the Soil Conservation Service of the U. S. Department of Agriculture will provide a generalized method of assessing soil permeability and soil purification capabilities. While more detailed site specific soils information may be available from well driller logs and construction feasibility studies, at this stage such site specific information is not necessary.

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*"Construction Grants Program for Municipal Wastewater Treatment Works: Handbook of Procedures." EPA. 1976. p. IV-52.

## EXHIBIT 2.3

## NATURAL AND PHYSICAL FEATURES

**CLIMATE**

- precipitation, humidity, temperature ranges, prevailing winds, insulation, evaporation potential

**TOPOGRAPHY**

**SOILS**

- types, limitations for on-site systems, frost depth, wetland locations

**WETLANDS**

**FLOOD HAZARD AREAS**

**RECEIVING WATER**

- Streams

  Drainage areas, flow characteristics, water uses, water quality classification, water quality data

- Ponds/Lakes

  Drainage areas, sources, elevation, acreage, depth (or profile), ownership/access, water quality and classification; uses

- Groundwater

  Aquifer characteristics, such as extent, flow, and saturated thickness; quality; uses

Information on wetlands is used in the facilities planning process to assess areas unsuitable for development. The information will also be used in assessing the environmental impacts of particular facilities. Basic wetlands areas can be determined from the U.S.G.S. topographic maps, though more data may be required to identify seasonal wetlands or provide more details. State regulatory agencies and 208 agencies may be useful sources.

Flood hazard areas are important to the facility planner in the siting of facilities and in determining areas that pose development constraints. They may have been defined on the basis of the 100-year flood plain for the study community through a HUD flood insurance rate study. In the absence of such data, HUD may prepare flood hazard maps on request. Otherwise, a variety of conflicting sources will have to be used, such as HUD preliminary "flood hazard maps" which in many cases are based on arbitrary distances from water courses. There may also be a local flood plain regulation in the zoning ordinance which restricts development in a floodplain area, based on arbitrary topographic contour elevation. Additional site specific flood elevation information may be available as needed in facilities siting from U.S.G.S., the State Department of Transportation, SCS, the Corps of Engineers, or the local highway department or conservation districts.

Information is needed to determine the potential impact of alternative disposal options on receiving surface water. In many cases, water quality constraints for certain water courses will be given by waste load allocations developed by water quality management agencies.

Explicit waste load allocations for ponds and lakes will probably not be available. As discussed in Chapter 4, water quality impacts related to on-site systems, in particular, may be important issues for surface water impoundments. The planner should collect readily available water quality information at the Community Profile stage on both streams and impoundments.

If on-site and land application systems are likely to be recommended in the planning process, groundwater quality impact analysis will be an important part of the overall alternatives selection process. It is essential, then, to acquire as much readily available groundwater data as possible in the community profile stage. Of particular importance in this stage is to identify existing and potential water supply groundwater aquifers. This identification stage should focus primarily on unconfined aquifers where there is potential for water quality impact from on-site systems, though well records should also be examined for pollution potential.

Ideally, the following groundwater information would be desirable for each of the groundwater aquifers in the study area.

- area extent of the aquifer(s)
- aquifer saturated thickness, depth and seasonal variation
- aquifer flow contours
- existing water quality
- existing uses

Saturated thickness and transmissivity information are perhaps optional for the level of water quality impact analysis proposed in this methodology. They do provide, however, an indication of the most significant aquifers in the community. A saturated thickness map will show where there are extensive deposits of saturated sand and gravel as well as the thickness of the saturated pervious materials. An important measure of aquifer suitability for the development of groundwater supply is aquifer transmissivity which is the capacity of the aquifer to transmit groundwater laterally, and thus influences flow rate. This factor is calculated as the product of the saturated thickness of the aquifer with the permeability of the saturated material.

The U.S.G.S Hydrologic Atlases, if available, are the best and most comprehensive sources of information. In many areas they will not be available, however, and the other U.S.G.S. sources plus any other easily available information should be used. If additional data are required later in the process, there may be unpublished data from many sources including U.S.G.S., the local building inspector, the local water department, area well drillers, and utility companies, as well as state agencies.

## 2.3 EXISTING WASTEWATER DISPOSAL PROFILE

One of the main purposes of the Community Profile is to determine the types and extent of existing wastewater disposal practices in the study area and to determine, as best as possible, the adequacy of these systems. For the purposes of the methodology, adequacy includes both operational performance and water quality impact.

### 2.3.1 Water Consumption Data

Estimates of current and future wastewater flows are based on existing water use data. Water use information is also important in the assessment of groundwater recharge impacts associated with households switching from on-site systems to centralized surface discharge systems. In accordance with the new Construction Grants regulations (40 CFR 35), water use information may be developed by one of two different methods.

The preferred method is to fully document water use and wastewater flow when records are available. However, water use records are likely to be available only for the public water service areas. In areas without water use or wastewater flow data, standardized per capita figures shall be used to estimate residential consumption. The following figures are suggested by EPA:

| | Gallons per capita per day |
|---|---|
| Non-SMSA cities and towns with projected total 10-year populations of 5,000 or less | 60-70 |
| Other cities and towns | 65-80 |

In many cases, there will be good data on water use, but little information on wastewater flows, for example where on-site systems are currently used, but there is public metered water. In these cases, the amount of water used for residential dwellings should be computed, and converted (using the population figures developed earlier) into per capita water use estimates. This will be a combination of domestic use, which would enter a wastewater system, and sprinkling use, which may be seasonal. Therefore, if there is a season when sprinkling is unlikely (e.g., winter in the Northeast), the estimates of residential water use should use data from that period. In areas with year-round sprinkling, an adjustment will have to be made to estimate wastewater flows per capita.

Water data on industrial, commercial, and industrial use should also be collected from meter records, where possible, since this will provide some flow estimates. If there are a number of residential or commercial records, some sampling may be required.

### 2.3.2 On-site Residential Wastewater Disposal

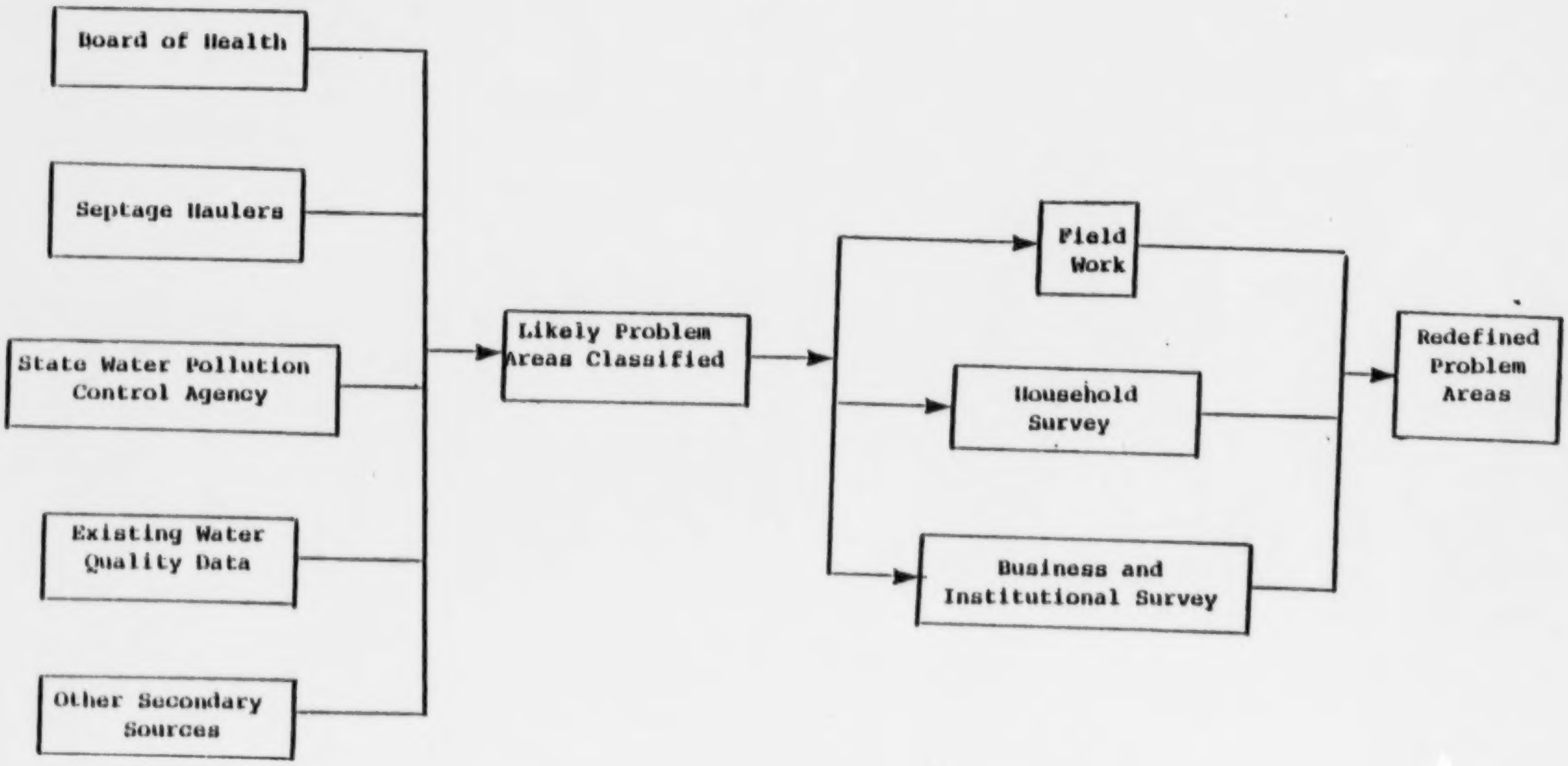
The Community Profile should determine the location of all on-site systems, as well as any easily obtainable information on system performance. Later, in the Field Work stage, additional data needed to evaluate performance in questionable areas will be collected.

As seen in Exhibit 2.4, there are two types of data gathering suggested. First, a number of secondary sources of data should be screened in this step, and surveys may follow in the Field Work step is necessary.

- Board of Health: This effort should include a discussion with the local board or sanitarian on the

EXHIBIT 2.4

APPROACH FOR DEFINING EXISTING ON-SITE PROBLEM AREAS


Board of Health
Septage Haulers
State Water Pollution Control Agency
Existing Water Quality Data
Other Secondary Sources
Likely Problem Areas Classified
Field Work
Household Survey
Business and Institutional Survey
Redefined Problem Areas

location of problem areas. The analyst would examine the files for the likely problem areas and attempt to obtain additional information as to why certain areas appear to be failing. In the Community Profile stage, the analyst should be principally concerned with the "commonly known problem areas". In the Field Work stage, the files of the Board can be consulted again for more detailed information if needed.

The following types of Board of Health data can be used if available to determine why certain areas are having problems:

- installation date -- problems may develop for systems installed in the wet season of the year or in years when groundwater levels are abnormally low due to drought, regulations also charge over time;
- sizing -- the system may have been undersized;
- site suitability -- information from percolation test or other soils tests may be available that indicate poor siting.

- Septage Haulers: From the Board of Health, the planner should determine the septage haulers that service the planning area. When cooperative, the septage haulers can be an excellent source of information. The best approach is to sit down with a preliminary map of "likely problem areas" and get the hauler's opinion. The hauler should be asked to disagree, verify, or add to the map. More specific information about amount of wastes, frequency of pumping, and disposal sites should also be obtained if possible.
- State Water Pollution Central Agency: Some of the on-site systems in the service area such as schools or hospitals, may have direct discharges that are regulated through the NPDES program. Data on permit conditions and influent/effluent quality should be collected, as for any public discharger.
- Water Quality Data: There may be a considerable amount of water quality data available -- for both surface and groundwater. This information collected as part of the effort to collect data on surface and groundwater in the Natural and

Physical Features Profile should be examined and interpreted for use in defining problem areas. Because of the diversity of sources for this information, extreme care has to be used in interpetation.

### 2.3.3 Existing Public Sewerage Facilities

Existing public sewerage facilities should be evaluated for adequacy and existing reserve capacity. The approach in the Community Profile stage should be to determine as much basic information as possible — detailed evaluation should be considered for the field work stage. The principal types of data suggested for collection for the Community Profile are listed in Exhibit 2.5.

## 2.4 EXISTING REGULATIONS AND INSTITUTIONS

### 2.4.1 Regulatory Constraints

The facilities analyst operates in a web of procedures outlined by the construction grants regulations. While these are important to the process of doing a facilities plan, there are additional regulatory constraints posed by Federal, State, and local laws and regulations that will be crucial to the screening and selection of alternatives. In the Community Profile, the principal regulatory constraints should be evaluated to aid in the screening of alternatives. These constraints will be particularly important in screening alternatives in terms of sites and treatment processes. If available, the constraints posed by an applicable 208 plan must also be determined.

### 2.4.2 Institutional Profile

An appropriate wastewater management system must be developed in the preparation of realistic alternatives. In many cases, the planner may include additional management duties as part of the recommended plan. It is important, therefore, to determine the existing management functions being performed and the institutional structure. Exhibit 2.6 is a suggested profile to use in interviewing the local on-site disposal management

## EXHIBIT 2.5

## INITIAL DATA REQUIREMENTS FOR EXISTING WASTEWATER FACILITIES

### UNSEWERED AREAS

- number of users and locations
- types and age of systems
- performance: failures and water quality effects

### SEWERED SERVICE AREA

- number of users
- population served
- miles of sewer line
- sewer map

### TREATMENT FACILITIES

- location
- receiving water
- age
- average daily flows
- peak flows
- flow composition--residential/commercial/industrial/institutional
- treatment process
- influent/effluent data
- design flows
- design treatment efficiencies
- operational problems
- available land for expansion

### SLUDGE TREATMENT AND DISPOSAL

### OPERATIONS AND MAINTENANCE STAFFING

### REVENUES/EXPENDITURES

### NPDES REQUIREMENTS

EXHIBIT 2.6

## EXISTING WASTEWATER MANAGEMENT AGENCY PROFILE

1. Organizational Basis
    - A. Statutory
    - B. Administrative
2. Date of Creation
3. Recent Jurisdictional Changes
4. Financing Authority/Sources
    - A. User Charges
    - B. Taxation
    - C. Government Appropriation
    - D. Grants
    - E. Loans
    - F. Other sources
5. Manpower
6. Budget Analysis
    - A. Major Line Items
    - B. Debt Structure
    - C. Trends
7. Organizational Structure
8. Data Collected
9. Relationships with State DWPC, Department of Environmental Health or Other State agencies
10. Intergovernmental arrangements with other local governments (e.g., members of sewer district)
11. Operating Constraints
    - A. Funding
    - B. Legal
    - C. Manpower
    - D. Other
12. Other responsibilities

gency and the local sewer board. For existing on-site systems, it will be important to find out about regulation of:

- Design
- Site Planning
- Installation
- Operation and Monitoring
- Maintenance, and
- Alteration

A list of dates when rules were modified may be important in classifying the existing sytems.

## 3.0 PROBLEM AREA IDENTIFICATION

This is the first data analysis step. The sources assembled for the community profile will be used to identify the types of wastewater facilities presently being used, and evaluate their performance. In some areas it will be quite easy to establish that the existing service is either adequate or inadequate. Where existing facilities are determined to be inadequate, the reason for this determination should be stated since this information will be essential for generation of alternatives to correct the existing problems.

Frequently the analyst will not be able to determine the adequacy of service from the information available. In this case, it is necessary to determine what additional information must be obtained in order to classify the facilities as either adequate or inadequate.

The criteria used to determine whether existing or proposed facilities are providing adequate service will vary from community to community. Water quality and public health standards will play an important role in the development of these criteria. Only technical issues should be of concern at this point in the planning process. Where a certain technology would provide the needed service if operated and managed properly, it should be assumed at this point that an appropriate management structure can be devised. Adequacy should, however, be defined to include the full 20-year planning horizon: if systems are expected to fail in large numbers in the near future, even with proper management, service should be considered inadequate. The facilities plan will cover the full period, and these systems could be replaced in a later phase, when they begin to fail.

For both developed and undevelopable land, the classification of wastewater service as adequate, with no anticipated problems given proper management, does not necessarily mean that existing technology will be employed in the final proposal. This classification simply means that it is not necessary to consider an alternative technology at these locations. It may, however, turn out later to be desirable to provide an alternative technology because of reasons such as efficiency of layout, economies of scale or anticipated difficulties in managing the existing technology.

### 3.1 LAND USE STATUS

Classification by land use status is the first step in the problem area identification process. Three broad categories of land use are of interest at this point in the planning procedure:

- Developed Land defined as all parcels which have already been developed.
- Developable Land defined as any parcels which may legally be developed. Physical characteristics of the site which may make development prohibitively expensive are not of concern at this point. Privately owned land currently used for agriculture and recreation should be included.
- Undevelopable Land includes all land which can not be legally developed. This category includes all public or privately owned land held specifically for the purpose of recreation or conservation. Power company and utility rights of way would also be considered undevelopable.

Each of these categories of land use has a slightly different status with regard to the facilities planning process. The federal Construction Grants Program has been devised primarily as a corrective mechanism. Thus, provision of facilities to improve wastewater management for developed areas with problems is the first priority. However, it is important to carefully consider the impacts of such facilities on future development and vice versa. Facilities (or excess capacity) to serve future growth will generally not be grant eligible. Finally, undevelopable lands, once identified, can generally be removed for the planning process since generation of wastewater is not anticipated at this locations. Where intense recreational activities are anticipated, this assumption would have to be changed.

Of course, as with all procedures recommended here, the categories can be modified to reflect the local conditions where required. For example, redevelopment may be occurring in some communities. Increased densities or conversion to year round occupancy can have a significant impact on the performance of existing waste water facilities.

### 3.2 DEVELOPED LAND

The next step is to classify all developed sites by the types of wastewater facilities currently employed and the adequacy of service. Here again, the classification should be modified to meet local circumstances and should be as detailed as possible given the amount of information available in the community profile. In particular, where facilities are deemed to be inadequate, it is important that the reason for this determination be clearly stated. Sub-categories could be used for mapping this information and to specify what additional information is required for areas where the adequacy of service is yet undetermined. The following general categories are recommended:

S = sewered
  S1 - No anticipated problems with existing systems, given proper management
  S2 - adequacy undetermined
  S3 - existing system inadequate

C = standard on-site
  C1 - No anticipated problems with existing systems, given proper management
  C2 - adequacy undetermined
  C3 - existing system inadequate

M = miscellaneous
  M1 - unusual on-site; no anticipated problems with proper management
  M2 - unusual on-site; adequacy undetermined
  M3 - unusual on-site; existing system inadequate

M4 - industrial

M5 - others

For the purposes of this project, standard on-site systems are to be defined for each community as those permitted for general application by local and state codes. Thus unusual systems would be those which would require special permits or approvals, etc. to be installed. In some states, "standard" may only be ST/SAS systems; in others, privies, mounts or evapotranspirtaion systems may be included.

### 3.3 DEVELOPABLE LAND

Finally, the developable land without existing service should be classified by its ability to be developed using presently available technologies. For areas adjacent to existing sewers this may involve the evaluation of whether the existing system can accept additional loadings. However, in the absence of new facilities, new development will have to rely on standard on-site systems, or perhaps small treatment plants. The density and types of development permitted, therefore, clearly influence the effectiveness of any proposed wastewater management facility. Since the nature of future development is always unpredictable, it is necessary to make guesses as to what types of development might occur. In most communities the uses and densities permitted under existing zoning would be a good start. If the community does not have zoning by-laws, then a more detailed examination of the historic pressures on development will be required. The growth and development portion of the community profile data can be used here.

As with developed sites, developable land can be classified by adequacy of service if no changes are to be made in either the technologies or the political situation:

D = Developable

    D1 = No anticipated problem with standard
         on-site systems, given proper management

D2 = Adequacy undetermined

D3 = standard on-site systems would be inadequate

Exhibit 3.1 illustrates how the existing wastewater facilities performance has been evaluated in our hypothetical community. In Exhibit 3.2, those areas of the community which are adequately and inadequately served, for whatever reason, are highlighted. The grey areas represent those parts of the community for which a determination of service adequacy cannot be made. It is in these areas that field work should be concentrated.

Experience with this Step

Exhibit 3.3 shows one of the three case study sites, which we have renamed "Btown". Exhibit 3.4 shows an overlay of soil characteristics and Exhibit 3.5 shows the land use information. The facilities plan for the site describes the existing data on system performance as follows*:

> "Recognizing that a substantial percentage of the existing systems are in excess of 10 years old, it was next attempted to determine the level of maintenance provided to the systems and the probable failure rate of those systems that were not adequately maintained. To accomplish this objective, a comprehensive review of all existing State and County Health and Water Quality Agency records was conducted. The results of this review were somewhat inconclusive, however, in that no public agency had conducted any comprehensive investigations into septic tank wastewater disposal procedures or effects prior to the current study.
>
> "A review of the liquid waste landfill disposal statistics for the Idyllwild sanitary landfill was subsequently performed in order to determine the frequency of septic tank failures within the service area. It was disclosed that the rate of septic tank failures was quite high.
>
> "When septic tank and/or subsurface disposal systems

---

*Source: Hirsch & Koptionak, San Jacinto Mountain Area Facilities Plan, 1978.

## EXHIBIT 3.1

## EVALUATION OF EXISTING SERVICE

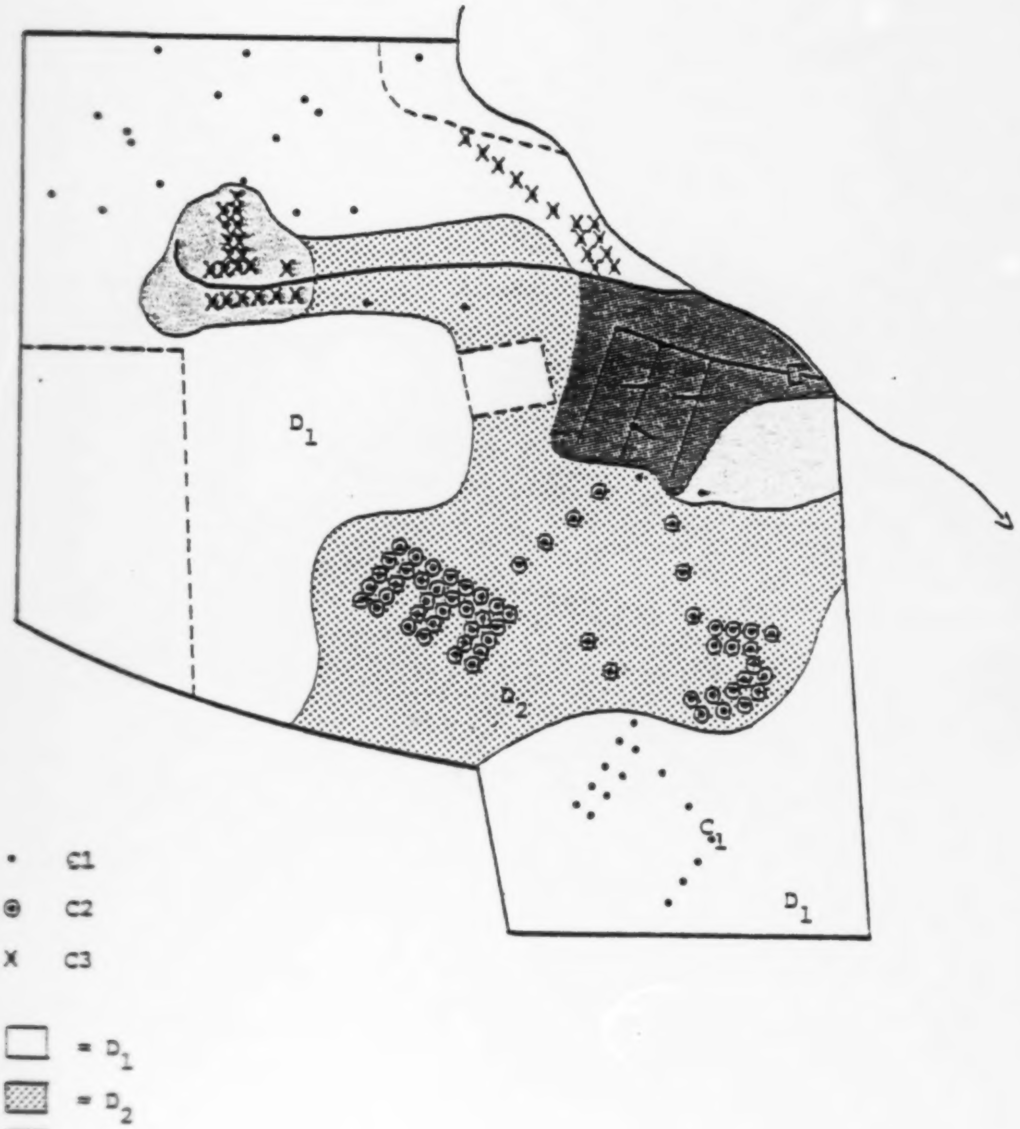
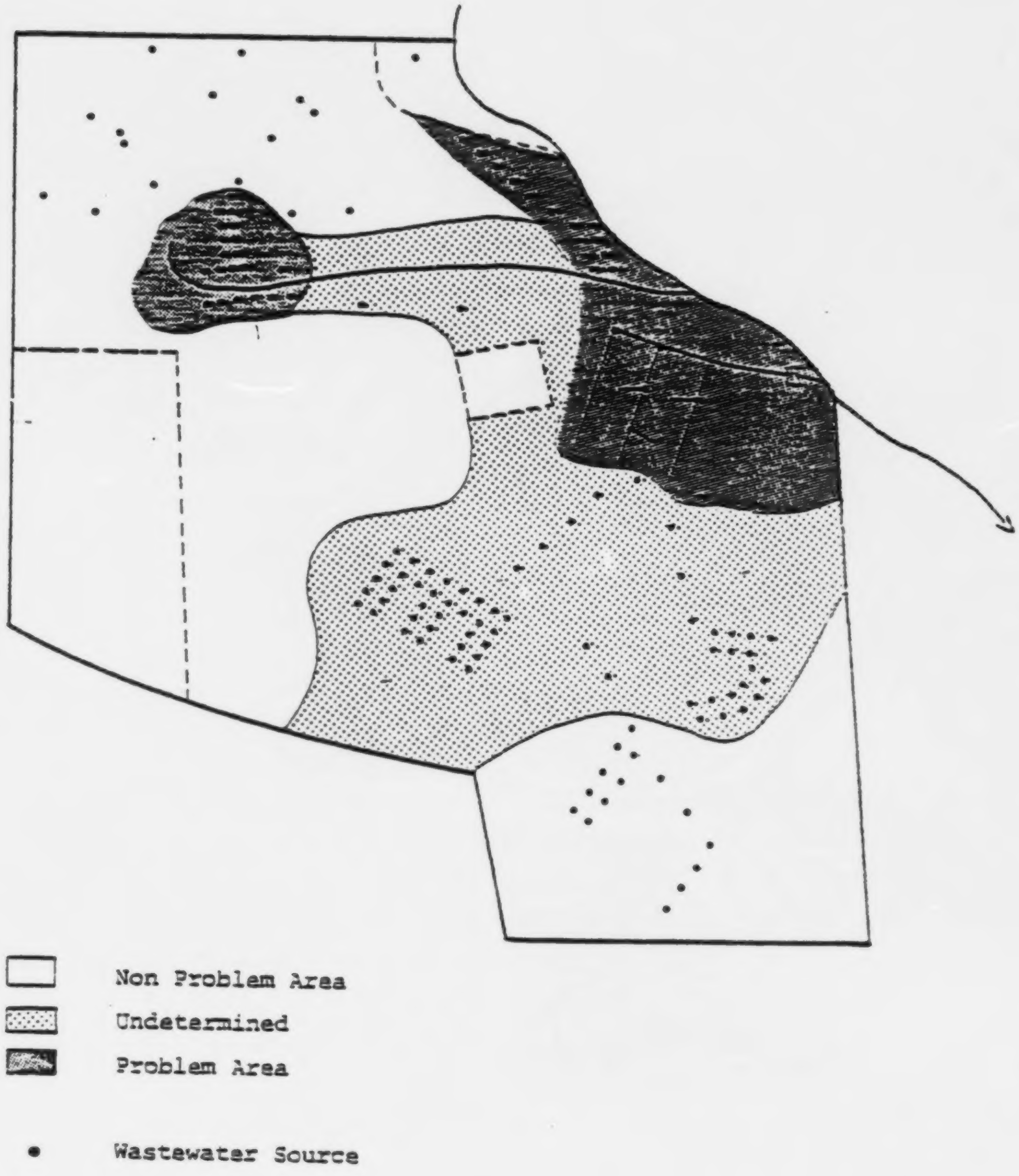

D1
D2
C1
D1
• C1
⊙ C2
X C3
☐ = D1
▨ = D2
☐ = D3
■ = S3

EXHIBIT 3.2

## PRELIMINARY PROBLEM AREAS



☐ Non Problem Area
▨ Undetermined
■ Problem Area
● Wastewater Source

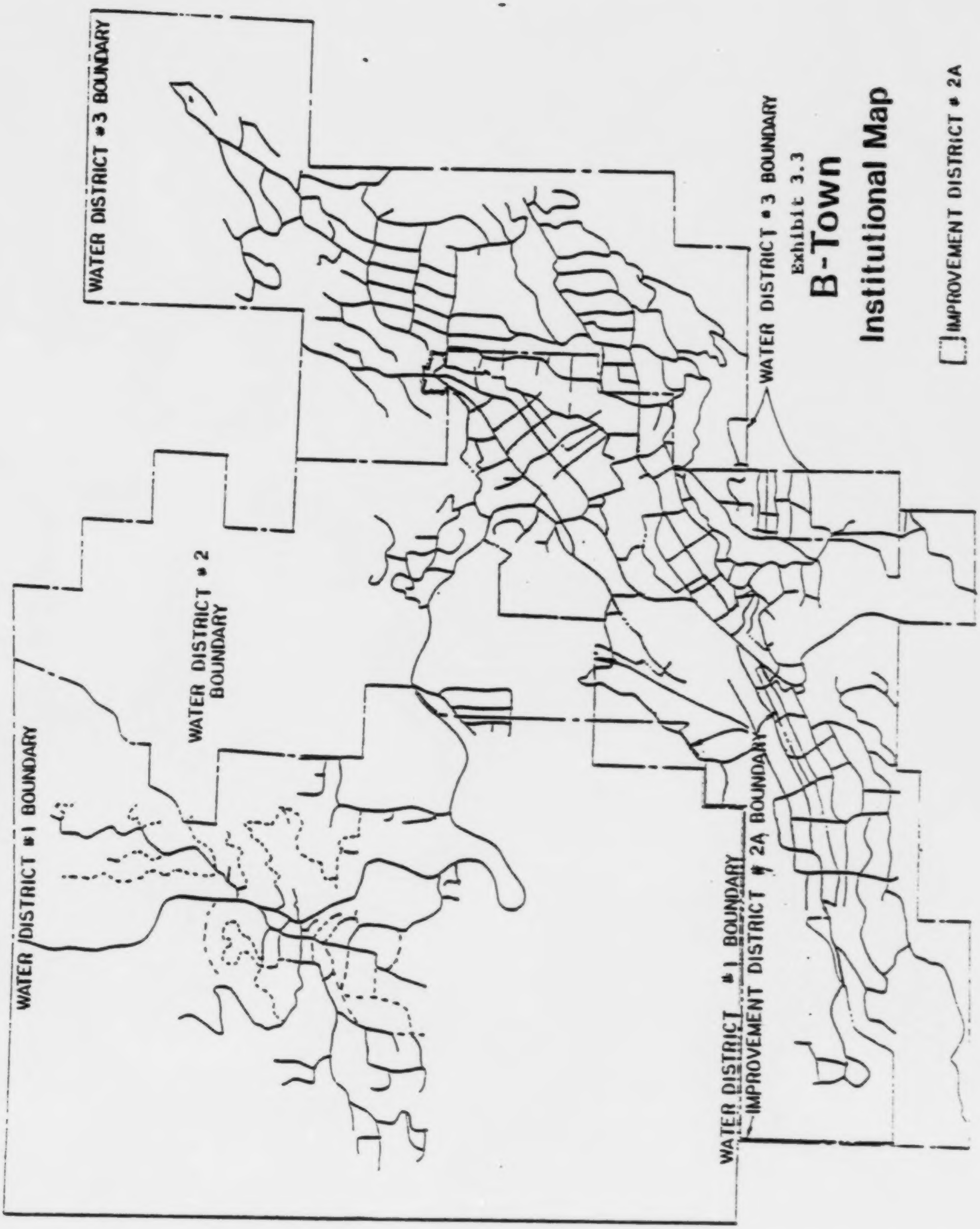


Exhibit 3.3

### B-Town
### Institutional Map

WATER DISTRICT #3 BOUNDARY
WATER DISTRICT #2 BOUNDARY
WATER DISTRICT #1 BOUNDARY
WATER DISTRICT #3 BOUNDARY
WATER DISTRICT #1 BOUNDARY
IMPROVEMENT DISTRICT # 2A BOUNDARY
☐ IMPROVEMENT DISTRICT # 2A

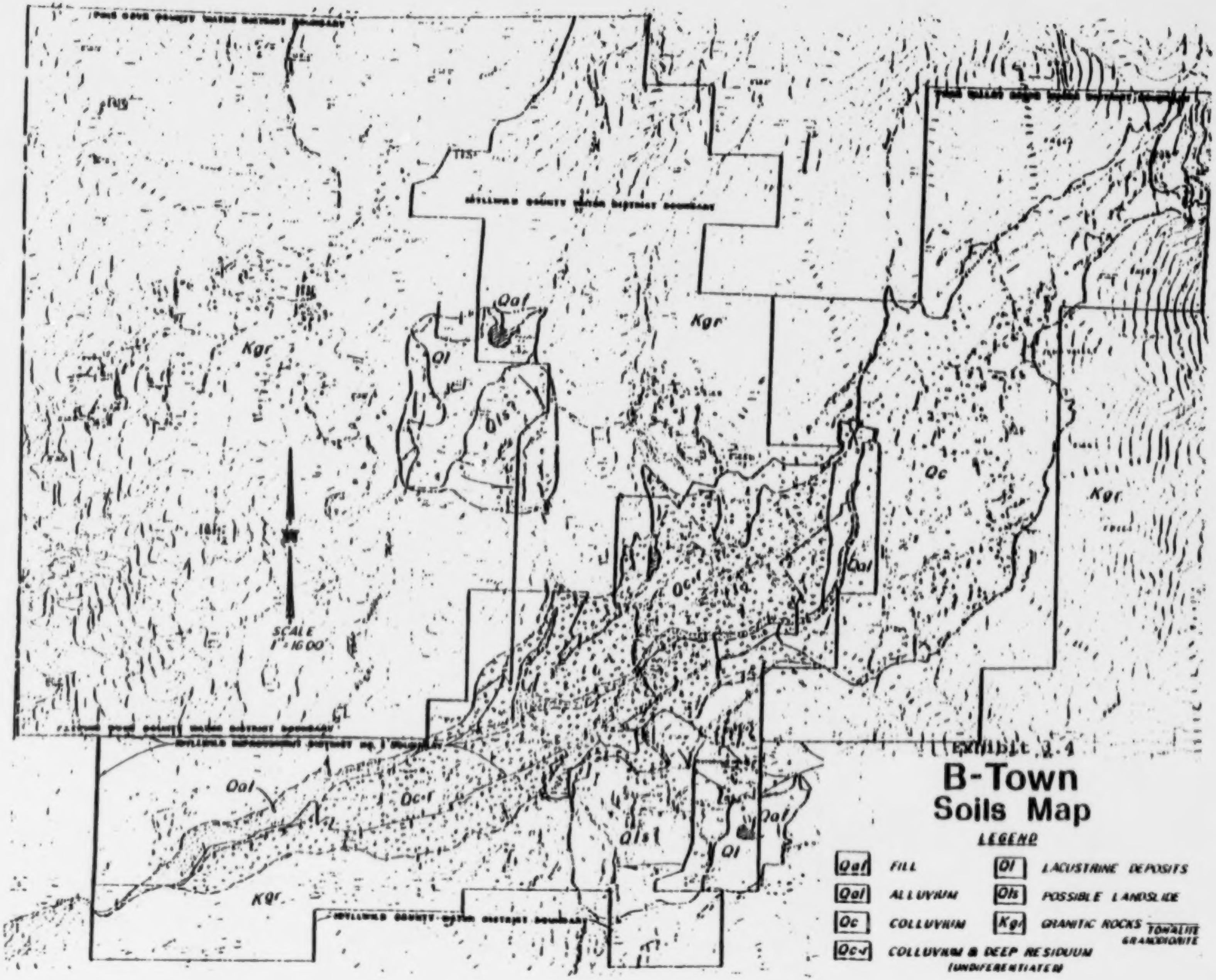

Kgr
Qaf
Ql
Qls
Qc
Qcr
Qal
SCALE
1" = 1600'
LEGEND
Qaf FILL
Qal ALLUVIUM
Qc COLLUVIUM
Qc-r COLLUVIUM & DEEP RESIDUUM (UNDIFFERENTIATED)
Ql LACUSTRINE DEPOSITS
Qls POSSIBLE LANDSLIDE
Kgr GRANITIC ROCKS TONALITE GRANODIORITE

EXHIBIT 3.4

# B-Town Soils Map

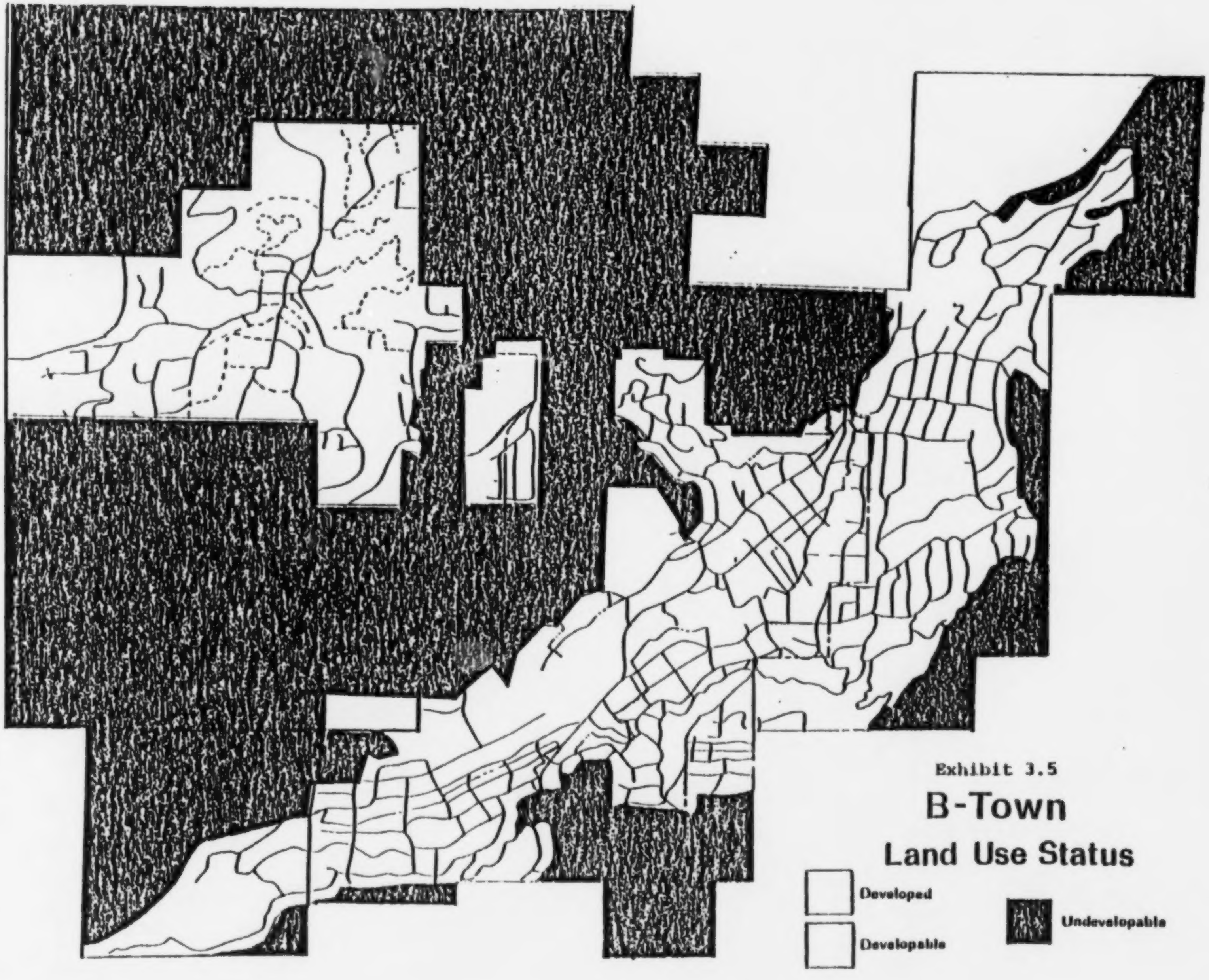


Exhibit 3.5

B-Town

Land Use Status

Developed
Developable
Undevelopable

fail to function adequately, the property owner retains a liquid waste hauler to pump and clean out the tank. Septic tank wastes are routinely deposited at the Idyllwild sanitary landfill. From a review of the records of the load deposited, it can be estimated how many septic tanks have been pumped out during a given period of time.

"Typically, a septic tank is pumped only when the owner is experiencing operating problems with the system. Interviews with liquid waste haulers disclosed that tanks are seldom, if ever, pumped on a routine, maintenance basis.

"During the 12-month period of January through December of 1976, the total number of loads dumped was in the range of 221 to 227. Of this total, approximately 90 trips were made by the Idyllwild Sewer District to dump sludge from the sewage treatment facility. This is not a routine occurrence, is not pertinent to the problem, and was therefore not included in the analysis. Deleting these 90 trips provided a net of approximately 135 loads.

"It should be recognized that approximately thirty percent of these loads represent liquid wastes from more than one septic tank, in that the pump contractors frequently pick up two loads from two separate residential systems in order to reduce landfill disposal fees. To partially balance this fact it should also be noted that there are occasional discharges to the landfill from holding tanks, and from septic tank systems from without the service area. These contributions are considered relatively insignificant.

"The total estimated number of septic tanks pumped in 1976 can be developed as follows:

> 168 trips x 130% = 218 loads
>
> assume approximately 18 loads from holding tanks or septic tanks from without the service area
>
> total number of septic tanks pumped = 200

The total number of septic tanks in the area is 2244 (2576 units less 332 sewer system connections).

"The estimated number of septic tank systems that had to be pumped in 1976 represents between 9% and

> 10% of the total estimated number of systems operating within the service area.
>
> "Communication with the major liquid waste haulers (septic tank pumping contractors) disclosed that virtually all of the septic tank systems that are pumped are pumped as a result of a malfunction in the system: backed up building sewer; blocked leach lines or septic tank; surfacing leachate; malodorous conditions, etc. Few, if any, systems are pumped as a routine, good housekeeping procedure."

Therefore, for the purposes of the analysis, the site was classified as shown in Exhibit 3.6.

In another site, "Atown", most of the data on existing systems showed them to be adequate, and there was SCS data available on soils characteristics. Exhibit 3.7 shows the soils data, and Exhibit 3.8 shows the preliminary problem identification, before field work. These problem areas were primarily identified thorugh use of development and soils maps, by identifying conflicts between the soils information on wetness, bedrock, and permeability and the existing developed sites. Field work was required to get further information on failures and actual problems with the existing systems.

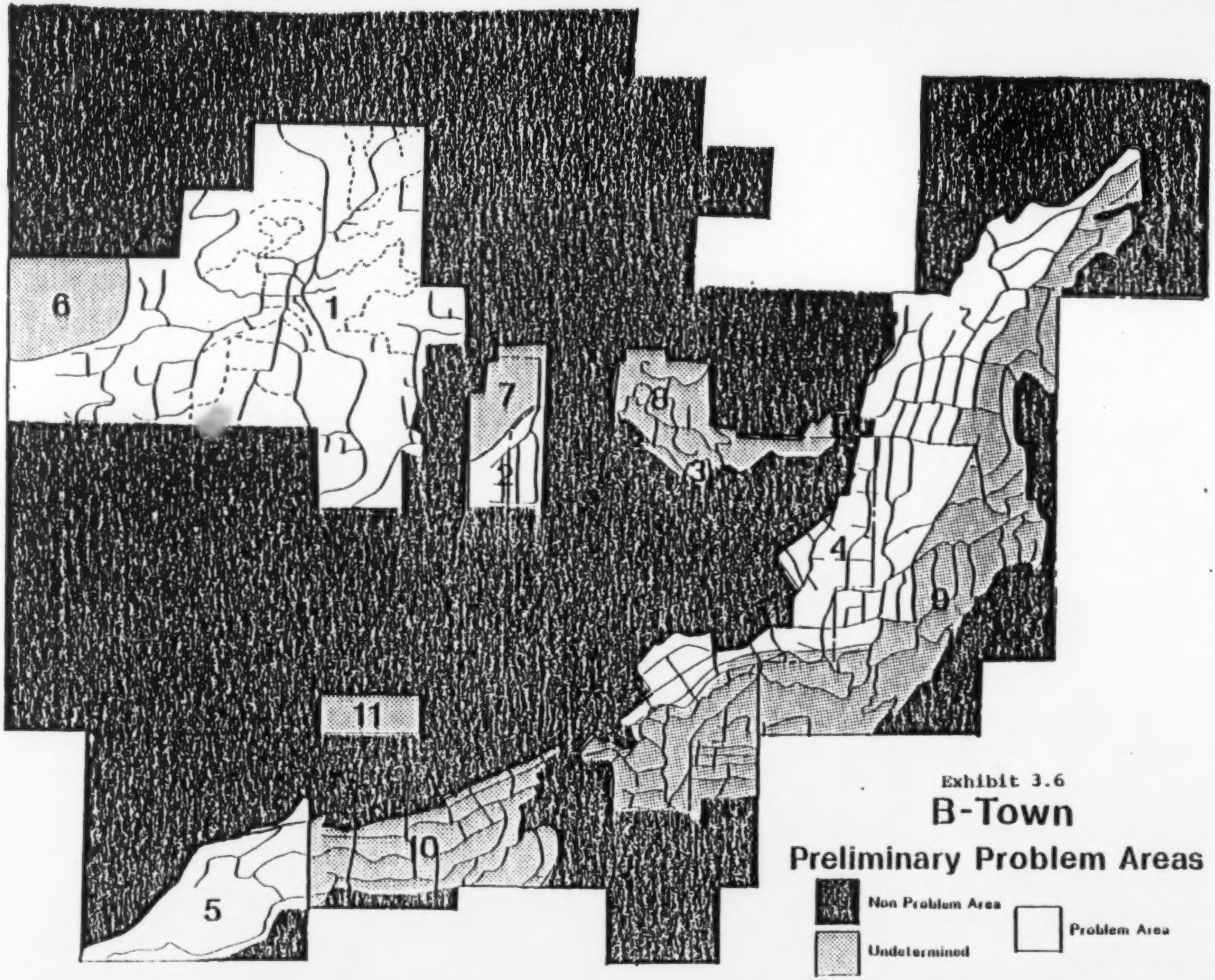
<br>

Exhibit 3.6

**B-Town**

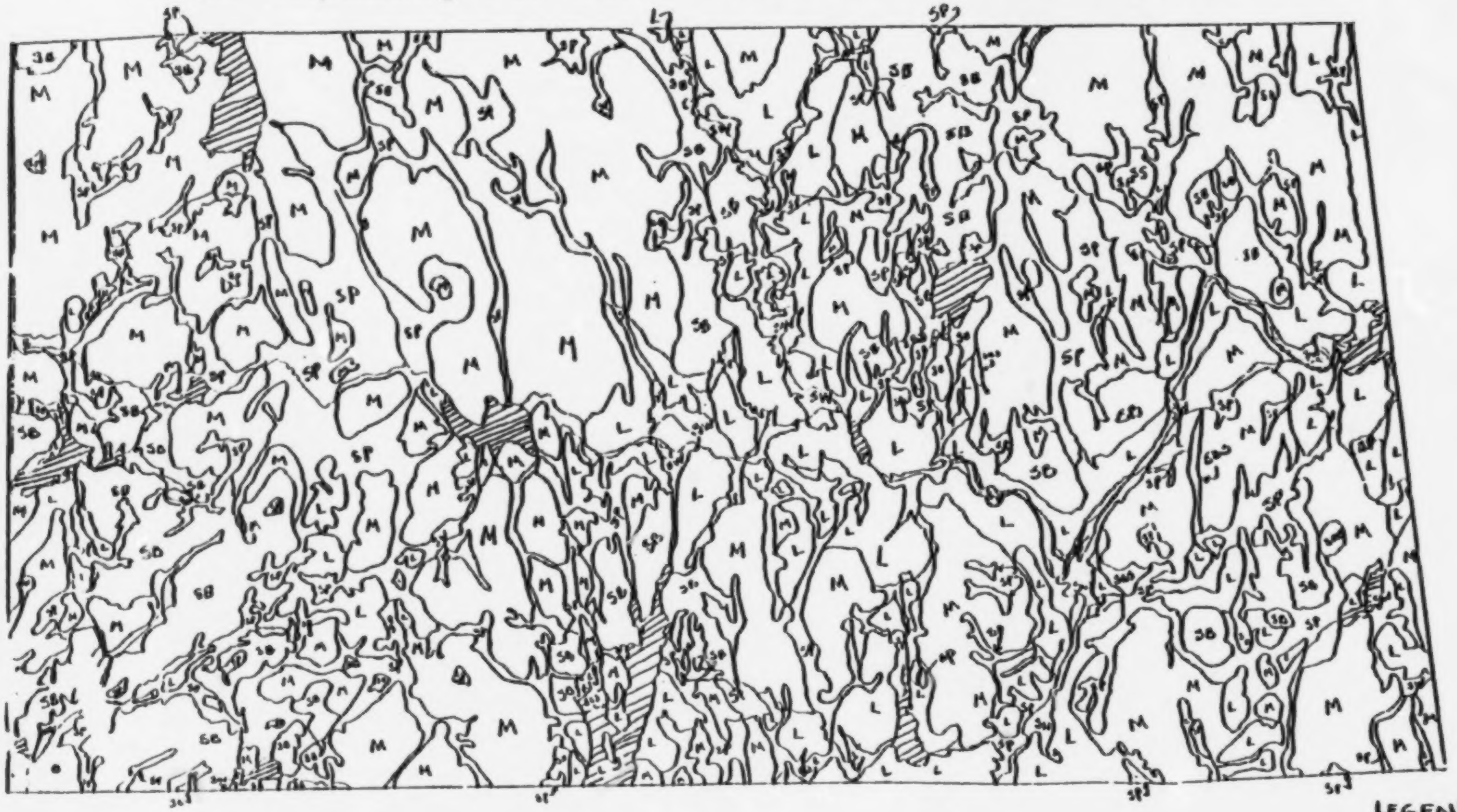
**Preliminary Problem Areas**

Non Problem Area
Undetermined
Problem Area
1
2
3
4
5
6
7
8
9
10
11

Exhibit 3.7

## A-Town

## Soils Capability For Conventional Subsurface Disposal



**LEGEND**

L SLIGHT
M MODERATE
SS SEVERE (slope)
SB SEVERE (BEDROCK)
SBS SEVERE (BEDROCK & slope)
SW SEVERE (WET)
SP SEVERE (PERMEABILITY)

Exhibit 3.8a

## A-Town

## Evaluation of Existing Service

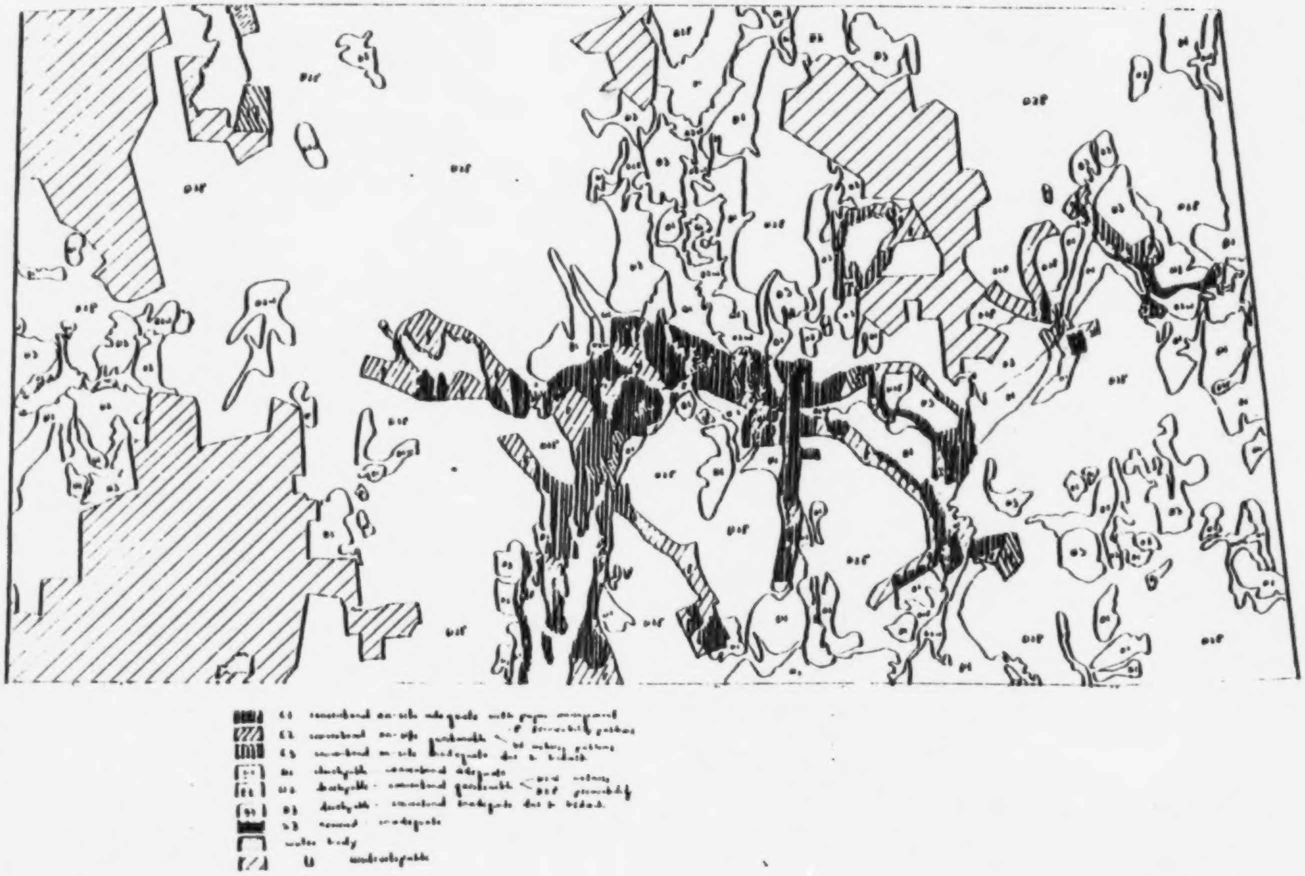
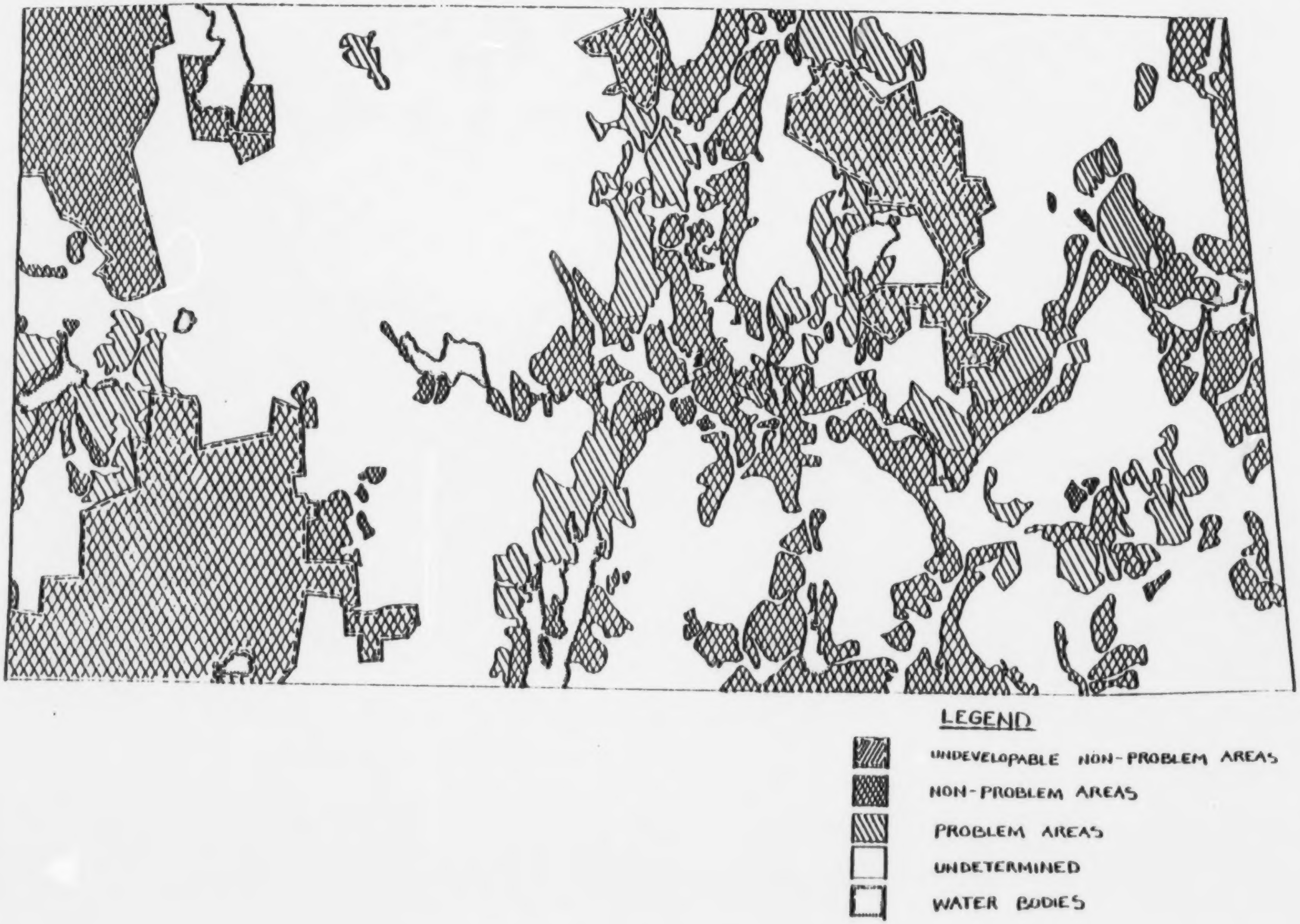

water body
U undevelopable

Exhibit 3.8b

## A-Town

## Preliminary Problem Areas


LEGEND
UNDEVELOPABLE NON-PROBLEM AREAS
NON-PROBLEM AREAS
PROBLEM AREAS
UNDETERMINED
WATER BODIES

## 4.0 FIELD WORK

The field work effort should concentrate on gathering the data necessary to determine the performance of systems whose adequacy has not been determined.

At the end of the problem areas identification phase, all portions of the community are classified. Some examples of where there is insufficient information to decide whether problems exist or not would include:

- areas using groundwater from water table aquifers, where there is limited data on groundwater flows and quality;
- areas with inconsistencies between apparent on-site system performance and soil ratings;
- areas with insufficient information about on-site system failures or about performance of existing centralized or package plants.

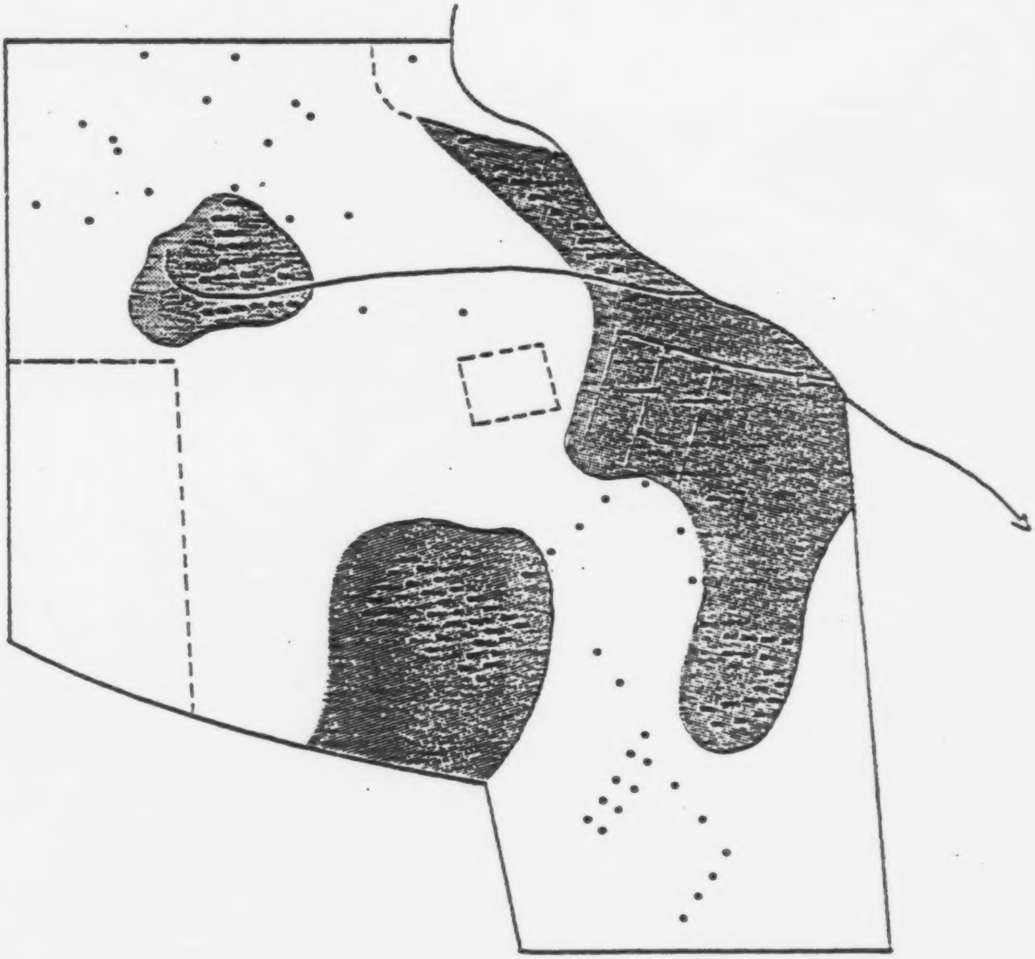
In essence, the Community Profile step collects the easy data--secondary source information, interviews with key officials, etc. These data are processed and analyzed, and the field work seeks to get further information only in the areas where the community profile is insufficient. The objective is to gain enough information to reclassify all these areas where adequacy is undetermined as either problem or non-problem areas. Exhibit 4.1 and Exhibit 4.2 illustrate how this reclassification could result in final problem area identification.. While the field work data collection will vary considerably from site to site, the following are examples of the sort of information which should be collected, where appropriate.

### 4.1 INFORMATION ON PERFORMANCE OF EXISTING SEWAGE TREATMENT PLANTS

If current treatment plants are not meeting their discharge permit requirements, it is important to find out why. For example, if the problem is only the management of a well-designed and correctly-sized system, this can be corrected with training,

EXHIBIT 4.1

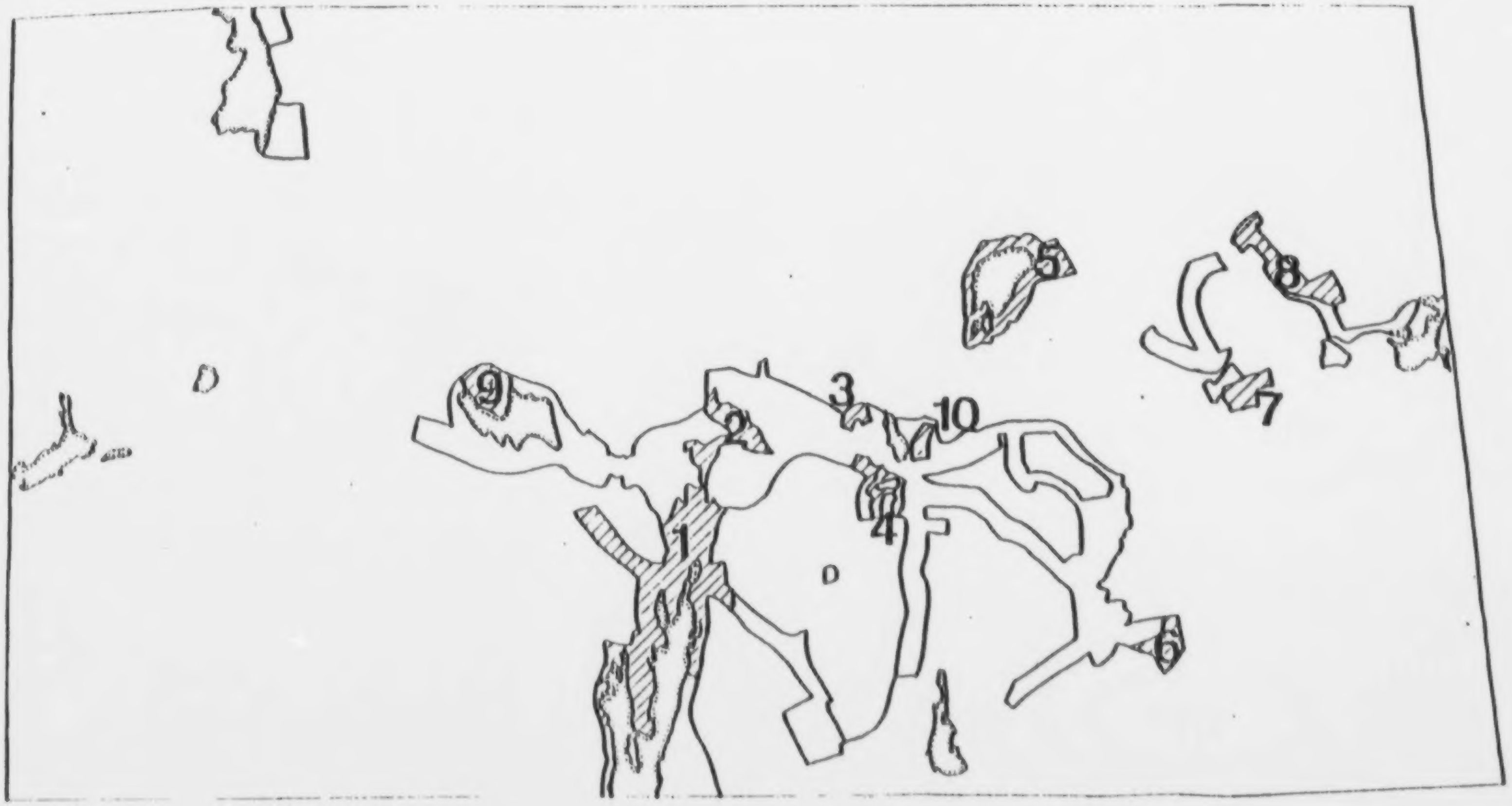
PROBLEM AREAS
(after field work)



● Wastewater Source

Exhibit 4.2

## A-Town
## Problem Area Identification



▨ DEVELOPED AREAS WITH PROBLEMS

☐ NON-PROBLEM DEVELOPED AREAS

D MOST LIKELY DEVELOPED AREA-NON PROBLEM technical assistance, and other operations support, without any requirement for large-scale upgrading or modification. On the other hand, if the problem is poor design, some modification of the capital equipment may be required. If the problem is simply insufficient treatment capability or hydraulic overload, then upgrading and expansion may be necessary.

The facility planner should work with the operators of any existing plants, and obtain information on the variation in wasteloads over time, on effluent quality, on operating procedures and so forth. Any unusual operating problems should be noted, so that they can be considered in the generation of alternatives and the selection of systems.

## 4.2 INFORMATION ON THE PERFORMANCE OF EXISTING ON-SITE SYSTEMS

While the Community Profile provided some information on the performance of on-site systems, more may be required to evaluate inconsistencies among the sources. For example, if the SCS maps rate an area as suitable for on-site systems, and the percolation tests look acceptable, but a high percentage of systems fail, the reasons for these failures should be established. Similarly, if systems appear to be working properly in an area with "severe limitations," they should be investigated. A windshield survey of the area, looking for direct discharges or other system problems, could be undertaken. Soil samplings and testing should be done, using an augur to get a few feet of core, and some inspection of actual systems might be considered, though this should probably be reserved to Step 2.

One of the most useful approaches at this point is likely to be a survey of households and firms in the undetermined area, to see whether the extent of existing problems is related to easily established causes such as leaky pipes or faucets. Seasonal occupany may explain the successful use of questionable systems. Similarly, large scale conversion of seasonal to year round occupany can result in a high failure rate.

All the field work data collected here, however, must be directed at a single goal: reclassifying areas where adequacy is undetermined as either acceptable for conventional on-site systems, or unacceptable. When a significant question remains, public health and environmental quality constraints should be considered paramount, and the site should be listed as a problem area, with documentation.

## 4.3 GROUNDWATER IMPACTS

Even when on-site systems appear to be operating correctly, they may have significant environmental impacts on the groundwater, or on associated surface waters. Where the water table is of sufficient depth, and the soils acceptable, the major impacts will arise from nutrients reaching the groundwater, or passing through the groundwater to surface water bodies. In addition, there is a potential for pollution of private and public water supply sources.

In the community profile, the uses of groundwater were identified, and the locations of water bodies. In addition, any easily available data on ground water movement or quality was gathered.

However, when there is a potential for nutrient entry to sensitive surface water bodies such as impoundments, or where an unconfined aquifer is used for drinking water, further information is likely to be required. If the water table aquifer is near the surface, a limited set of borings should be taken to observe groundwater gradients and soil types, so that movement patterns can be predicted. These data will make it possible to analyze whether existing or new on-site systems or other forms of land application have a significant potential for polluting any usable groundwater supply, or surface water body. Sampling and analysis should also be done of existing water quality in both ground and surface water sources, where a pollution potential exists.

Obviously, if the worst-case groundwater analysis (the mass-balance approach described in the appendix) shows no potential for significant pollution, further data collection is not required. This field work, therefore, is directed at the cases where there appears to be a chance of a problem based on the simplistic analysis, but where further evaluation may lead to elimination of the site as a problem area.

In some cases, it may be possible to use driller's logs or related information in preference to doing new borings. However, the cases of interest are specifically those where the groundwater is relatively near the surface, so that borings will be relatively simple and inexpensive, in most areas.

## 4.4 OTHER SOURCES, AND PROBLEMS

One of the steps of the community profile was to gather information on land use plans for developable areas, so that these could be compared with constraints caused by the limitations of conventional on-site wastewater technology. If land use plans and similar data are not available from the community (i.e., no zoning, no building inspection, no formal planning), it will be necessary to gather such data by interviewing realtors, builders, and community officials, as noted in the growth and development profile.

These are just a few examples of the types of data to be collected in the field work phase to fill in gaps in the data based assembled for the Community Profile. To a certain extent, creativity will be required in identifying sources and in recognizing data needs. We believe this step will be extremely significant particularly in determining whether on-site or alternative approaches should be attempted. The actual requirements of the field work phase will vary considerable from case to case, since both data needs and sources will vary greatly.

## 4.5 EXPERIENCE WITH THE FIELD WORK

In developing the sample residential survey form (Exhibit A.8 in the Appendix), the USR&E staff gathered information from various sources, including consultants, Planners, and Reviewers, on the use of such surveys in practice. Since it will not be possible to evaluate the usefulness of this data collection tool through the case study process, an effort has been made to assess past experience in the field.

A residential survey can provide valuable information which when combined with data from other sources such as public health records, records on septage collection, spot field checks, solid maps and public participation, can help pinpoint problem systems and help identify probable solutions. Facilities Plan reviewers should be able to critically evaluate the use of residential surveys as a key component in the planning process.

The first step towards the development of a residential survey should be an assessment of the availability and quality of other data sources to determine the goals and objectives of the proposed survey. Where adequate data is available the use of a residential survey may not be necessary. In most cases the survey results would be used to verify the preliminary problem areas identified on the basis of the community profile or to reclassify undetermined areas. In addition, information collected may help identify the types of problems and their probable cause. In the extreme case where very little information is available on system performance or soils, a residential survey may take on a much more important role as the primary data source. In such cases the reviewer should be very diligent in reviewing the survey design and analysis.

At the same time that the survey goals are defined, the area of the community to be surveyed should be identified. In cases where information is only needed in a few undetermined areas, door to door surveys may be the most appropriate. In other cases even though the information from particular areas will be more critical, a community-wide mail survey may be appropriate (in extremely small communities a door to door survey may be best).. In general, a door to door survey will provide more complete results.

At this point, a questionnaire and analysis methodology should be generated which will most effectively meet the local needs. It is important to develop the analysis methodology simultaneously with the questionnaire to insure that all the appropriate information is requested and that extraneous information is not requested. The USR&E questionnaire is fairly comprehensive and would be used in a situation where other data sources were particularly weak.

The USR&E staff and their consultants reviewed the results of a residential survey conducted in a small New England community in order to evaluate the practical application of this data collection tool. The example case involved a community-wide mail survey of approximately 1440 residents. The response rate of just under 40% highlights one serious limitation of mail surveys. Another limitation was noted in that several of the questions were somewhat confusing and consequently it is difficult to interprete some of the results.

It is difficult to predict if a higher response rate would be achieved with anonymous questionnaires. It is not clear whether the request of a name and address, as done in the example case, discouraged residents with problems for responding. If anonymous responses are encouraged, an alternative means of locating the respondant (such as the use of coded questionnaires) should be considered. If coded questionnaires are used, correlation could easily be made between response rate and perceived problems.

In the example case the analysis methodology was developed separately from the questionnaire and the maximum use was not made of the data collected. In cases where survey data analysis will be done by computer, questionnaires coded by location would greatly simplify the analysis procedure and increase the usefulness of the results. Similarly the questionnaire should be developed to minimize the general coding effort.

In addition to being aware of the goals and objectives and survey and analysis methodology, the reviewer must know how the survey results were utilized in the problem area identification and/or alternative generation phases of the facilities planning process. In the example case this link is not clearly made. Particular concern should be paid to areas where the survey results are in conflict with other data sources. The reviewer should be satisfied that such conflicts have been resolved and sufficient provisions have been made to correct any problems. It is important that residential surveys not be conducted merely to fulfill some agency requirements, but that the results be used to achieve an appropriate facilities plan.

## 5.0 GENERATION OF ALTERNATIVES

Once the base map indicating problem areas (Exhibits 4.1 and 4.2) has been developed, the next step is to generate technological alternatives for the individual problem areas. Issues of operation, maintenance and management of both existing and proposed facilities will be addressed during succeeding phases of the planning process; the objective at this point is to identify several technically feasible alternatives for solving wastewater management problems, for more detailed evaluation later.

The procedure for generating alternatives should be followed for each problem area. For the sake of simplicity, areas experiencing the same problems for the same reasons may be grouped and treated as a single problem area, even if the areas are not continguous.

### 5.1 DETERMINE EFFLUENT STANDARDS

The effluent quality standards which must be met in order to discharge wastewater from the problem area at all possible discharge points should be identified. In most cases, effluent standards for discharges to surface water will be relatively easy to calculate since water quality limits have been set by the states. Systems which depend on evapotranspiration or discharge directly to the atmosphere should not require compliance with any water effluent standards.

Discharges to the land, either surface or subsurface, pose the most difficult problem since very few water quality standards have been established. Also, it is very difficult to predict the groundwater quality impacts of wastewater discharges to land. Yet, since many alternative systems depend on land application or subsurface discharges, the establishment of standards for soil to groundwater discharges is crucial to evaluating the potential use of these systems. In the absence of regulations, the analyst should set standards which will not lead to adverse impacts on groundwater.

As part of the community profile and/or the Field Work sections of the methodology, the uses of the community's groundwater resources should have been established. Water quality standards for each aquifer should be based on the uses and potential uses of that resource.

## 5.2 EVALUATE IMPACTS OF LAND USE REGULATIONS

In those developable areas where it is predicted that conventional on-site systems would not provide adequate service (i.e., class D3) non-structural solutions should be examined. In particular, it should be established whether reducing the density of development permitted under local codes would allow the use of conventional on-site systems. In these cases, changes in land use regulation necessary to achieve the lower density goals should be analyzed and included in one or more of the alternatives generated for that particular problem area.

## 5.3 SCREENING TECHNOLOGIES

The Appendix summarizes the various technologies available for collection, treatment and disposal of wastewater residuals. There are several alternative technologies, which can be employed for each unit process, and an almost unlimited number of feasible process trains. The task of sorting through this maze to select the most appropriate technologies for a given problem area is difficult. The task was somewhat easier in the past since a strong bias in favor of conventional gravity sewers reduced the number of options to be considered.

To simplify the selection process it is recommended that the feasibility of several generic technologies be examined for each unit process. If any can be eliminated at the outset the number of alternatives to be considered can be greatly reduced. The reason for eliminating any generic types of technologies should be well documented.

Exhibit 5.1 shows a checklist of the various technology options considered in the case studies. Similar checklists could

## EXHIBIT 5.1

## PROCESS SCREENING CHECKLIST FOR AREA

Job: ____________________ Problem Area: ________________

Date: ____________________ Engineer: ____________________

| Process | Check if Unaccept-able | Reasons |
|---|---|---|
| **In-house**<br>water conservation-toilets<br>water conservation-graywater<br>graywater reuse<br>waterless toilets<br>other: ____________________ | | |
| **On-site Treatment & Disposal**<br>septic tank<br>aerobic system<br>filtration<br>SAS<br>evaportranspiration<br>disinfection<br>surface discharge<br>other: ____________________ | | |
| **Transport**<br>conventional sewer<br>vacuum sewer<br>holding tank/truck<br>grinder pump/pressure sewer<br>effluent pump/pressure sewer<br>small diameter effluent sewer<br>other: ____________________ | | |

## EXHIBIT 5.1

## PROCESS SCREENING CHECKLIST FOR AREA (Cond.)

| | | |
|---|---|---|
| Centralized treatment<br>headworks<br>primary<br>anaerobic treatment<br>secondary-filtration<br>secondary-fixed biomass<br>secondary-suspended biomass<br>secondary-ponds<br>advanced<br>disinfection<br>transport to plant outside area<br>other: ____________________ | | |
| Centralized Treatment and Disposal<br>SAS<br>infiltration<br>irrigation<br>evaporative ponds<br>other: ____________________ | | |
| Centralized disposal<br>surface water outfall<br>other: ____________________ | | |

## EXHIBIT 5.2

## PROCESS SCREENING CHECKLIST FOR AREA

Job: Atown Problem Area: 5

Date: July 20, 1978 Engineer: S.C.

| Process | Check if Unacceptable | Reasons |
|---|---|---|
| In-house | | |
| water conservation-toilets | x | not worth retrofit |
| water conservation-graywater | x | not worth retrofit |
| graywater reuse | x | not worth retrofit |
| waterless toilets | | |
| other: | x | |
| On-site Treatment & Disposal | | |
| septic tank | | |
| aerobic system | | |
| filtration | | |
| SAS | x | bedrock-not enough* |
| evaportranspiration | x | climate |
| disinfection | x | |
| surface discharge | x | |
| other: | x | |
| Transport | | |
| conventional sewer | | |
| vacuum sewer | | |
| holding tank/truck | x | too expensive |
| grinder pump/pressure sewer | | |
| effluent pump/pressure sewer | | |
| small diameter effluent sewer | | |
| other: | x | |

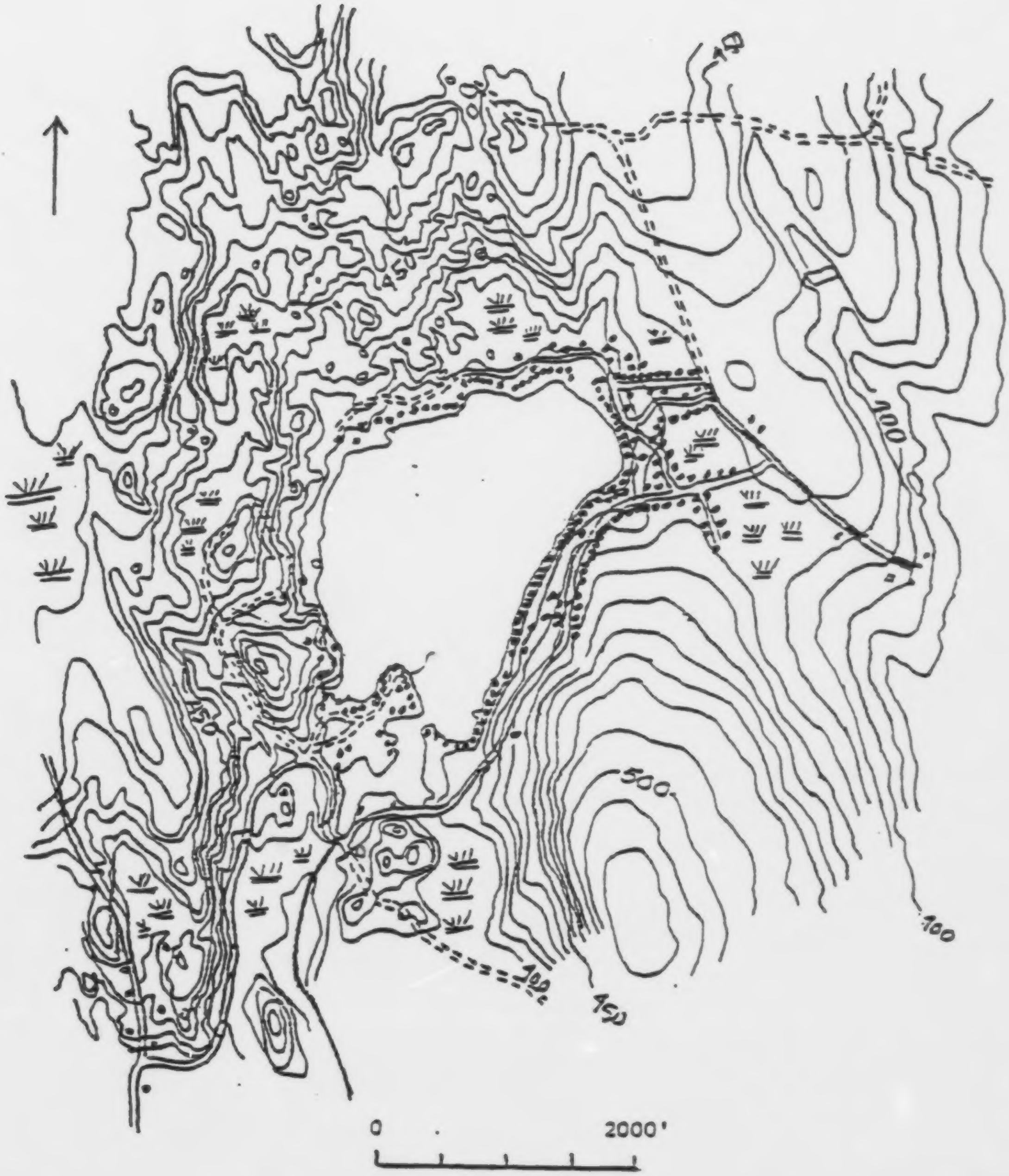
*room for mounds.

## EXHIBIT 5.2

## PROCESS SCREENING CHECKLIST FOR AREA (Cond.)

| | | |
|---|---|---|
| Centralized treatment | | |
| headworks | | |
| primary | | |
| anaerobic treatment | | |
| secondary-filtration | | |
| secondary-fixed biomass | | |
| secondary-suspended biomass | | |
| secondary-ponds | x | not enough land |
| advanced | x | not required |
| disinfection | x | not required for land app. |
| transport to plant outside area | | |
| other: ____________________ | | |
| Centralized Treatment and Disposal | | |
| SAS | | |
| infiltration | | |
| irrigation | | |
| evaporative ponds | x | no land |
| other: ____________________ | x | |
| Centralized disposal | | |
| surface water outfall | x | no discharge allowed |
| other: ____________________ | | |

EXHIBIT 5.3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PROBLEM AREA #5: BASE MAP OF EXISTING SYSTEMS

- individual on-site septic tank/SAS

Reproduced from best available copy.

be developed to include other processes by the practicing engineer. This checklist is used for the first step in screening alternatives. In essence, it requires the engineer to document why certain technologies have been eliminated from further consideration, at least in the first iteration. Some will be eliminated community-wide (such as evapotranspiration where the climate is unsatisfactory). Other will be eliminated for the specific problem area (such as SAS over bedrock). The checklist simply documents the reasons for eliminating these alternatives for each specific problem area. Exhibit 5.2 shows a completed checklist for one of the problem areas in Atown, which is mapped in Exhibit 5.3.

One of the most important considerations in evaluating unit process alternatives is their requirements for residuals disposal (sludges, septage, screenings, etc.). These materials can often be the constraining factors which make implementation of an alternative impossible, and they should be considered here in screening the options. However, the overall sludge management plan for the area will depend on the total set of residuals produced for all systems, and should be developed later, in the generation of community-wide alternatives.

The second step in screening technologies is to see what complete process operations are still available for the specific problem area. Exhibit 5.4 (a & b) shows the unit processes arranged as a flow chart, which is used to identify remaining process trains. In Exhibit 5.5 (a & b), the processes which have been eliminated for the particular problem area have been removed from the flowchart, leaving a much more limited set of options. At this point, these options are the feasible set for the problem area; subject to further analysis, it appears that they will be technically acceptable solutions, and solutions which are worth further consideration on other grounds.

The third step in screening alternatives is to select a set of process trains for further study. It is imperative that the

CHART 1

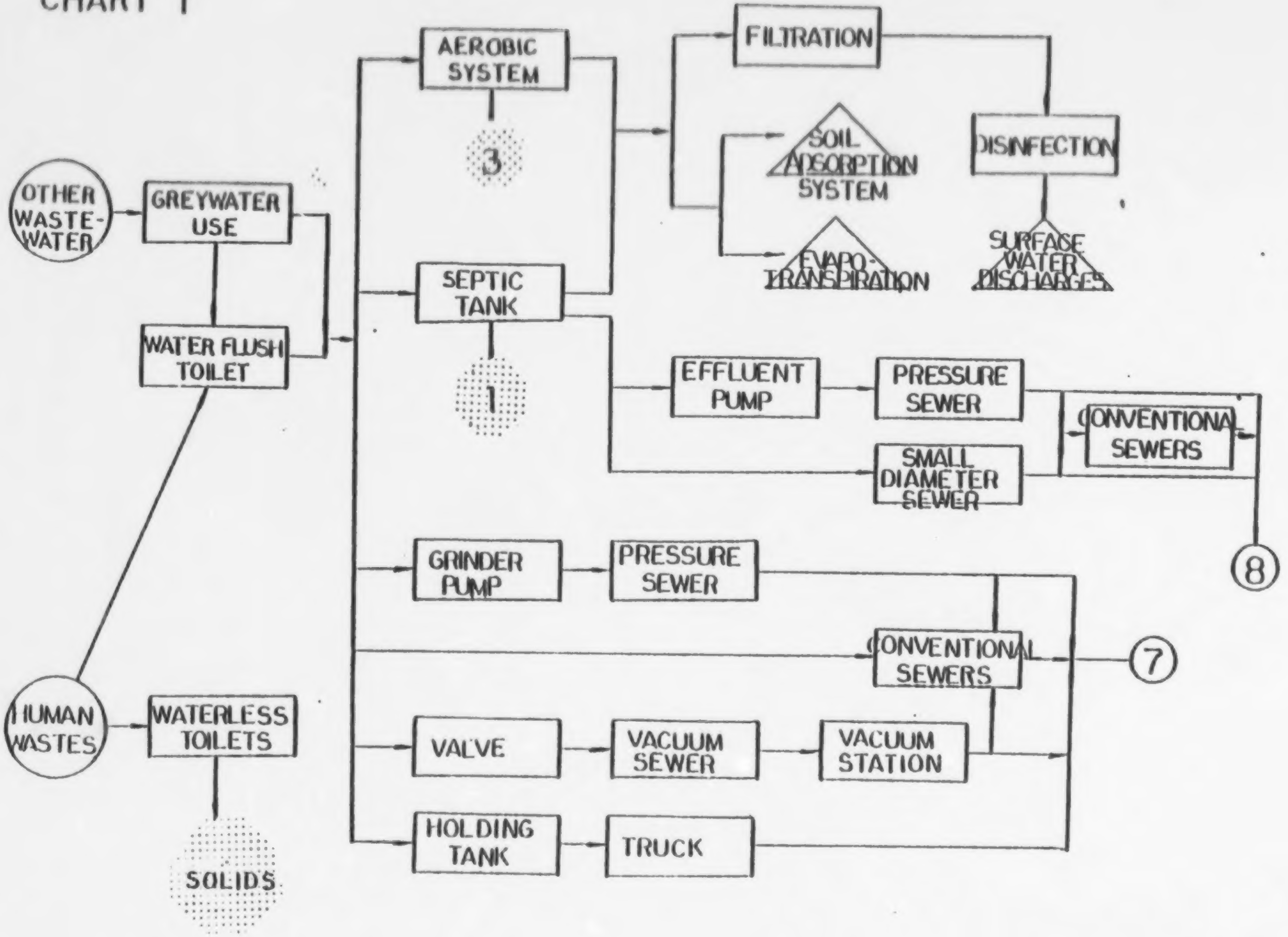

OTHER WASTE-WATER
GREYWATER USE
WATER FLUSH TOILET
HUMAN WASTES
WATERLESS TOILETS
SOLIDS
AEROBIC SYSTEM
3
SEPTIC TANK
1
FILTRATION
SOIL ADSORPTION SYSTEM
EVAPO-TRANSPIRATION
DISINFECTION
SURFACE WATER DISCHARGES
EFFLUENT PUMP
PRESSURE SEWER
SMALL DIAMETER SEWER
CONVENTIONAL SEWERS
8
GRINDER PUMP
PRESSURE SEWER
CONVENTIONAL SEWERS
7
VALVE
VACUUM SEWER
VACUUM STATION
HOLDING TANK
TRUCK

EXHIBIT 5.3a

PROCESS FLOWCHART

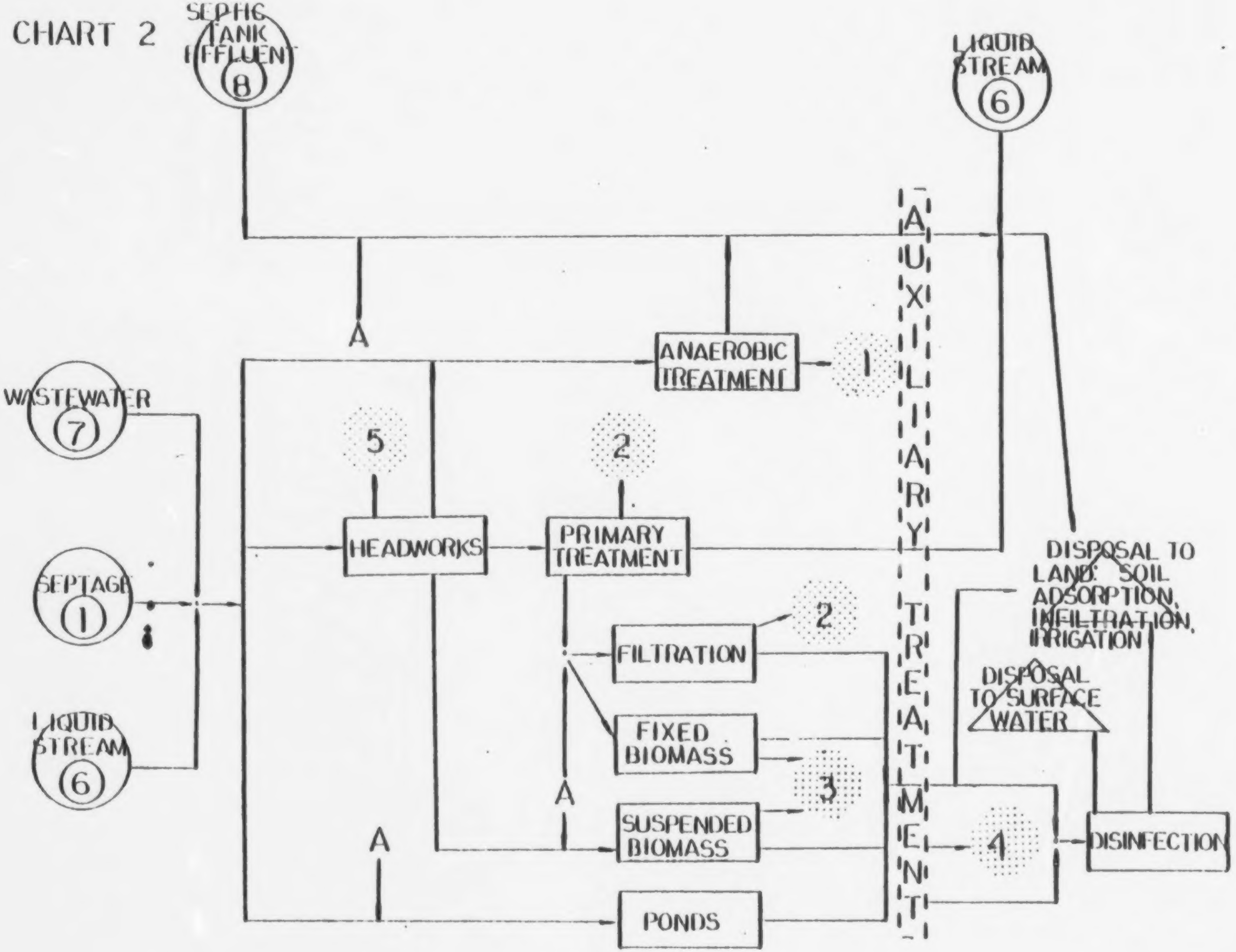


CHART 2
SEPTIC TANK EFFLUENT
8
LIQUID STREAM
6
WASTEWATER
7
SEPTAGE
1
LIQUID STREAM
6
A
ANAEROBIC TREATMENT
1
5
2
HEADWORKS
PRIMARY TREATMENT
AUXILIARY TREATMENT
DISPOSAL TO LAND: SOIL ADSORPTION, INFILTRATION, IRRIGATION
FILTRATION
2
DISPOSAL TO SURFACE WATER
FIXED BIOMASS
A
3
SUSPENDED BIOMASS
A
4
DISINFECTION
PONDS

**EXHIBIT 5.3b**

**PROCESS FLOWCHART**

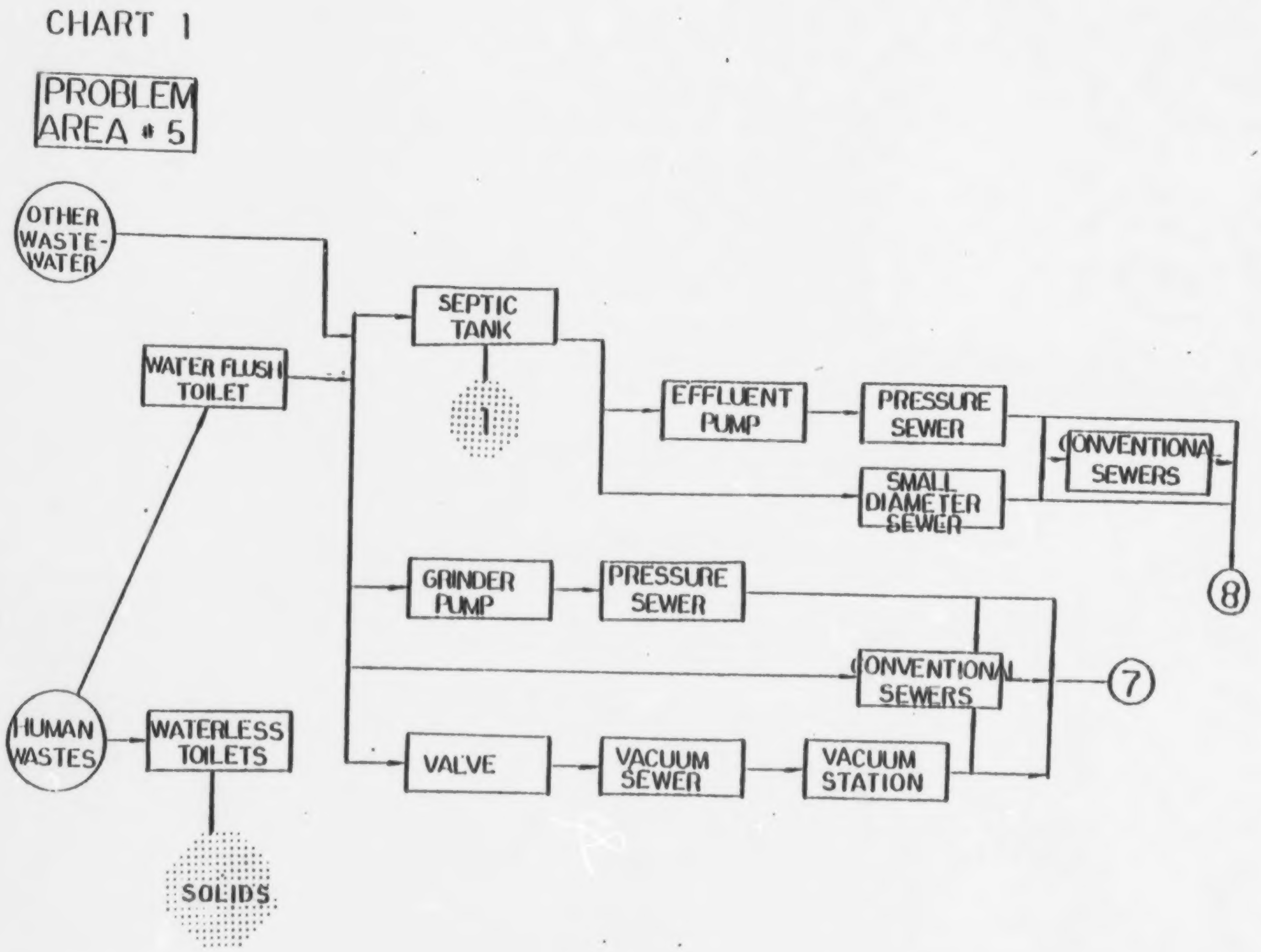


CHART 1
PROBLEM AREA # 5
OTHER WASTE-WATER
HUMAN WASTES
WATER FLUSH TOILET
WATERLESS TOILETS
SOLIDS
SEPTIC TANK
1
EFFLUENT PUMP
PRESSURE SEWER
SMALL DIAMETER SEWER
CONVENTIONAL SEWERS
8
GRINDER PUMP
PRESSURE SEWER
CONVENTIONAL SEWERS
7
VALVE
VACUUM SEWER
VACUUM STATION

EXHIBIT 5.4a

PROCESS FLOWCHART - ATOWN PROBLEM AREA 5

CHART 2

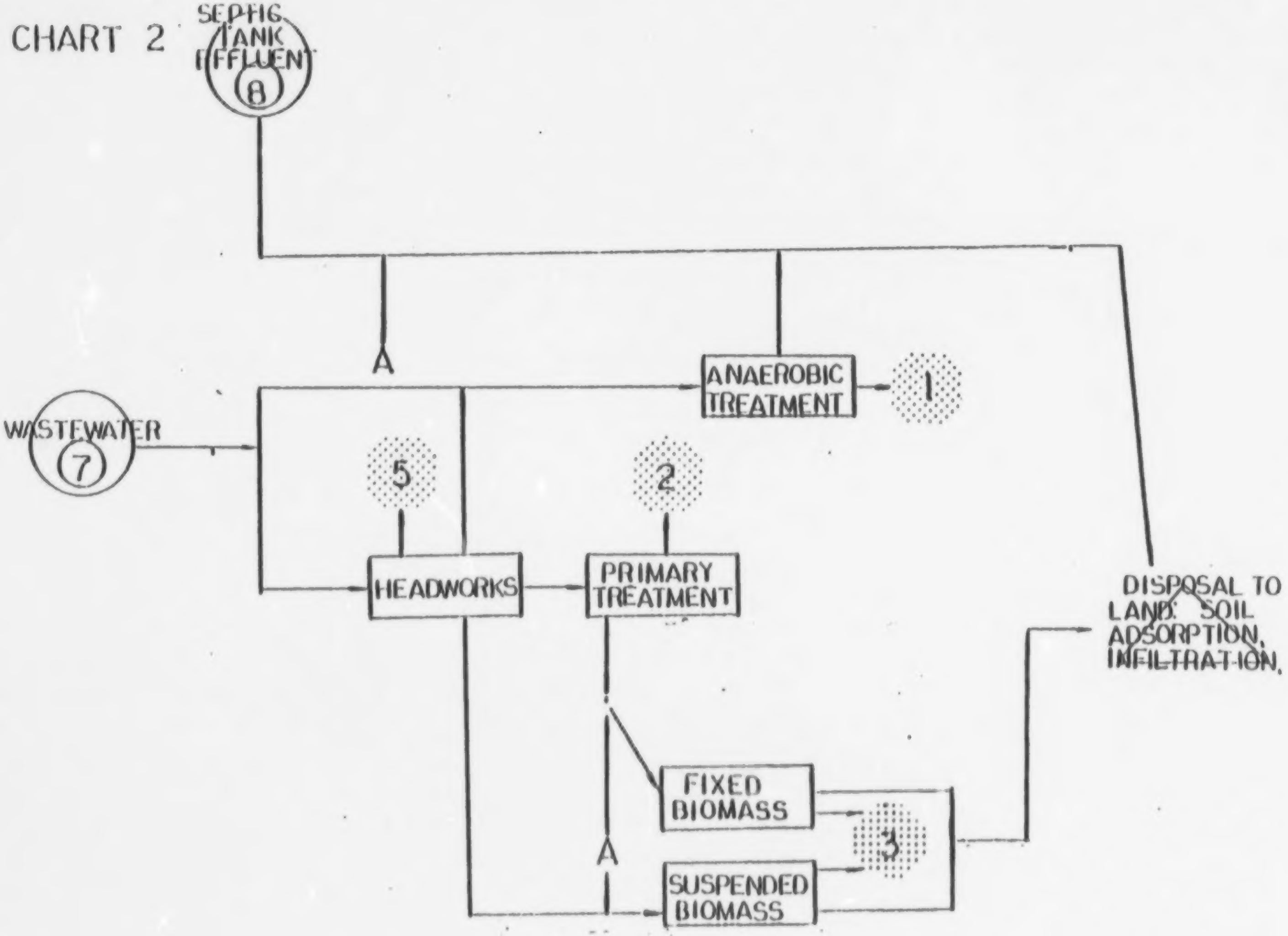

SEPTIC TANK EFFLUENT
8
WASTEWATER
7
A
ANAEROBIC TREATMENT
1
5
2
HEADWORKS
PRIMARY TREATMENT
DISPOSAL TO LAND: SOIL ADSORPTION, INFILTRATION,
FIXED BIOMASS
3
A
SUSPENDED BIOMASS

EXHIBIT 5.4b

PROCESS FLOWCHART - ATOWN PROBLEM AREA 5 set selected be chosen from all parts of the flowchart, not just a single section. For example, if on-site and land application alternatives were technically feasible, the selected process trains should not be only vacuum, pressure, and conventional sewers, all leading to an activated sludge plant. Alternatives should be chosen from the available options so as to include as much variation as possible, with professional judgment used to select the most attractive choices. Figure 5.6 highlights the process trains chosen for the Atown problem area; based on the case studies, 3-4 options per problem area appears reasonable.

Once the technologies are selected, they still must be applied to the individual problem area. This is conventional engineering practice, with one limitation: at this point, we are only concerned with solutions for the individual problem area, and are not combining problem areas. Thus, the solution may be to sewer the area for transportion with other wastes to an off-site treatment plant, but we are not, at this point, interested in plant locations or technologies. On-site and small-scale options, such as community septic tanks, are considered fully here.

Since the solutions are not complete for the community, it it not possible to perform economic comparisons between alternatives at this point. Thus, the major purpose of this step is to place the options in the problem areas, and develop the information necessary to analyze effectiveness, environmental impact, and cost of the community-wide alternatives of which these may be a part. The community-wide systems will include a number of other aspects besides these individual solutions, of course: interceptor networks, if required; centralized treatment plants; management options for "non-problem" areas; sludge and septage management, and the like.

EXHIBIT 5.6

## CHOSEN ALTERNATIVES FOR PROBLEM AREA 5, ATOWN

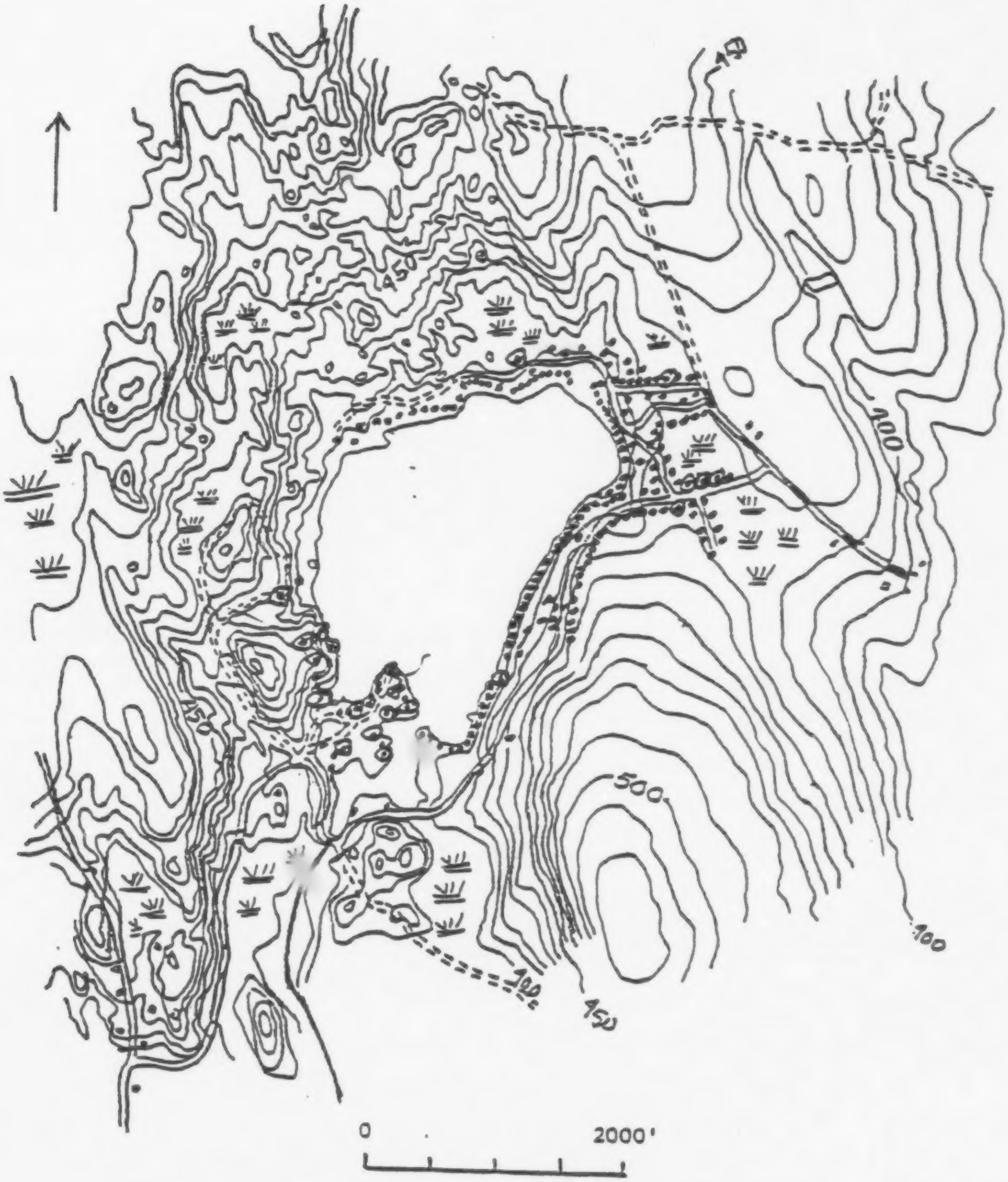
1. Waterless Toilets/Existing Systems for Greywater: Since there are major problems with systems being too close together, and with distance to bedrock, the use of waterless toilets has the potential of reducing wastewater loads enough to allow the existing systems to operate effectively on the greywater stream only.

2. Conveyance to Subsurface Disposal: This system would use the existing (or new) septic tanks, with STEP or Small diameter gravity sewers used to convey the wastewater to communal subsurface disposal fields.

3. Localized Treatment and Disposal: This system would use a more extensive conveyance system to transport the wastewater to a package plant for the area, and from their land application (after secondary treatment).

4. Conveyance Outside: Under this system, the wastewaters for the area would be collected and transported to a treatment plant outside the immediate area, where the wastes would be treated in combination with those from other problem areas.

EXHIBIT 5.7a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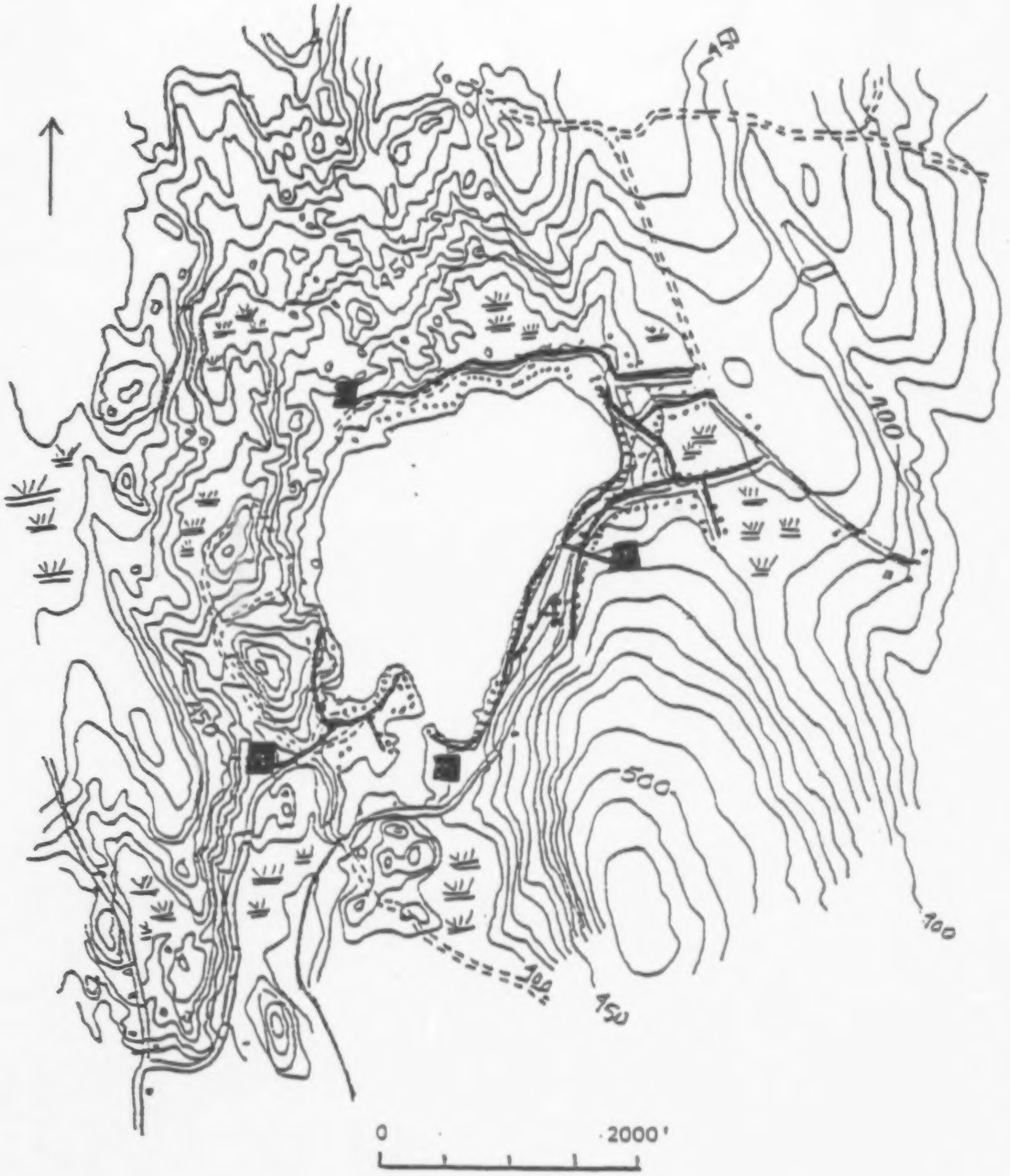
2000'

PROBLEM AREA #5, OPTION A: Installation of waterless toilets and use of existing septic tank/SAS for graywater

- • residences
- ● septic tank/SAS systems with rehabilitation required

EXHIBIT 5.7b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400
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2000'

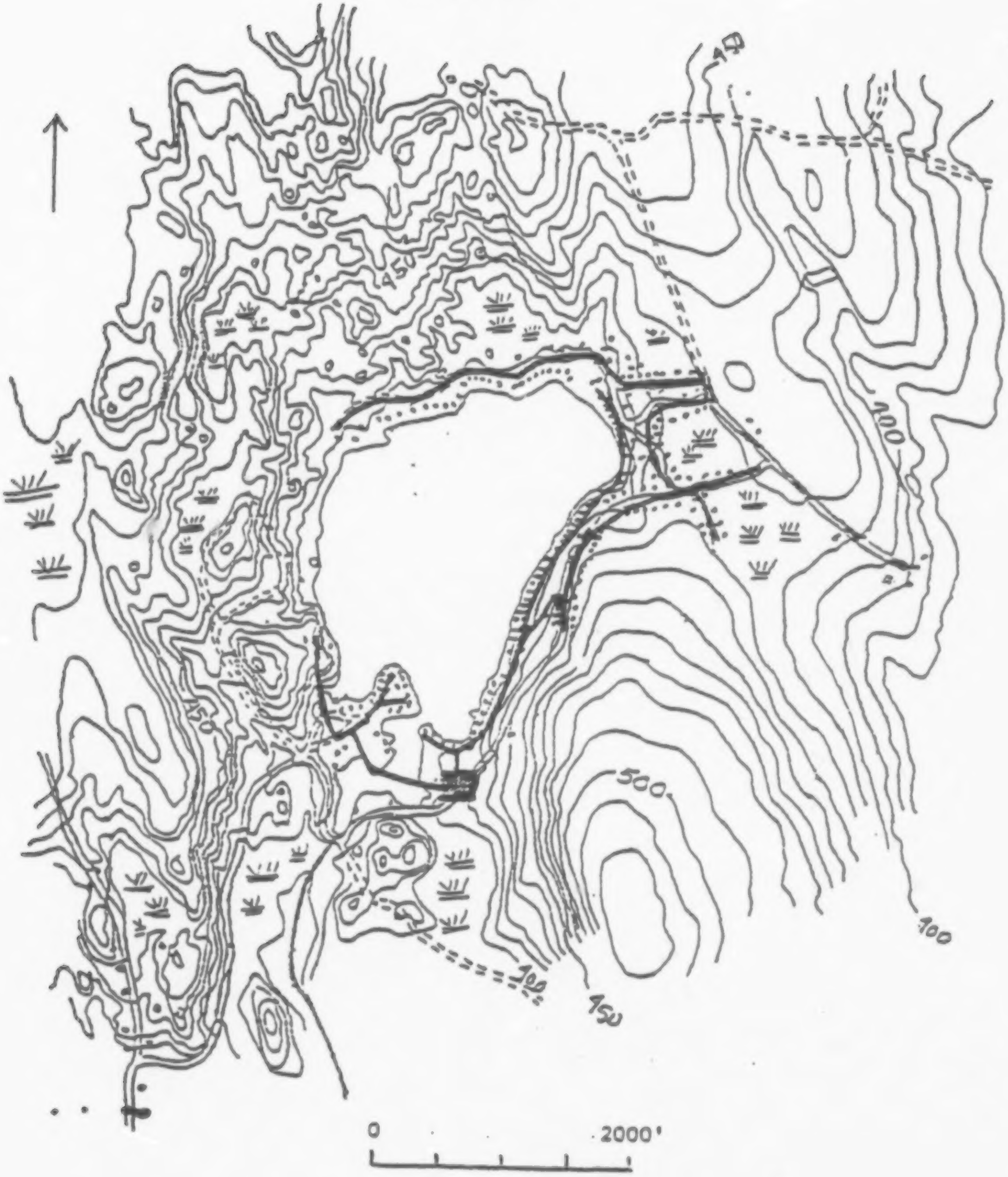
PROBLEM AREA #5, OPTION B: Effluent sewers to subsurface disposal

— STEP and small diameter effluent sewers

■ Subsurface disposal fields

• Individual septic tanks at residences

EXHIBIT 5.7c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PROBLEM AREA #5, OPTIONS C & D: Transport to package plant (C) or to pumping outside of the area for centralized treatment (D)

— gravity and pressure sewers

■ package plant or central pumping station

## 6.0 DEVELOPMENT OF COMMUNITY WIDE SYSTEMS

A set of alternative technologies have been generated in previous steps for each of the problem areas within the overall planning area, and it is necessary to develop Community Wide Service Systems. The objective is to integrate possible technological and managerial programs for both the problem and non-problem areas into an effective implementable program. A five-step process is suggested:

- Evaluation of technologies for compatibility;
- Definition of community-wide systems from the individual options;
- Generation of multi-area alternatives, where appropriate;
- _Development of solids management alternatives;
- Generation of management requirements and approaches;

## 6.1 EVALUATION OF TECHNOLOGIES FOR COMPATIBILITY

This is, to some extent, a judgment step. The technological options for each area of the community are arrayed, and this step attempts to eliminate options which are incompatible with each other, or which impose unnecessary requirements on the community. An obvious example of the latter situation would be the choice of two technologies in different areas which have the same performance requirements. If use of a single technology could lead to reduced maintenance costs for spare parts, and reduced training needs, that approach would be preferred. Compatibility for residuals management is also an important consideration.

## 6.2 DEFINITION OF COMMUNITY SYSTEMS FROM THE INDIVIDUAL PROBLEM AREA OPTIONS

At this point in the process, we have a number of problem areas with sets of system options proposed for each. We may also have some developed non-problem areas, which will require management systems and which may be served, if appropriate; and some undeveloped non-problem areas, which may also be served. In general, the goal of this stage of the process is to generate options which are likely to be effective, but which show a range of solutions for the community. Diversity is to be maximized across the set of community-wide service systems.

The first step, shown in Exhibit 6.1 for Atown, is to array the alternatives considered in each problem area. Individual technologies for conveyance and treatment are not of particular interest here, since they may depend on the choices in other areas (see below); instead, the concern is with the overall types of systems being used.

The second step is to choose some decentralized system options, such as those described in Exhibit 6.2, and shown in Exhibits 6.3-6.5. These are chosen as representative of specific objectives, such as "maximum use of on-site systems", for alternative #1, or "minimum maintenance".

Next, various levels of centralization should be considered, as described in Exhibit 6.6 and mapped in Exhibits 6.7-6.9. These were developed in this case by looking at the area of town which required sewering and treatment plant construction, and expanding the sewered area primarily in the direction of the required discharge site, which was downstream in a lower-quality reach. In other communities, the choices of where sewering is most attractive can generally be made fairly easily, and the initial sewered areas expanded as appropriate.

Once these rough community-wide options are defined, detailed technology choices become fairly clear. For example, in alternative #2, a great deal of reliance is being placed on individual septic tanks and leaching fields. Since septage collection and disposal plans will have to be made, for these systems in any case the use of effluent sewers (pressure and gravity) makes sense, as does maximum use of communal subsurface fields. This will minimize the number of maintenance and operations tasks, and simplify

## EXHIBIT 6.1

## ALTERNATIVES FOR PROBLEM AREAS

| PROBLEM AREA | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PROBLEM AREA ALTERNATIVES | A. Use compost toilets and existing systems for graywater to minimize extent of sewering; otherwise like B. | A. Mounds where required | A. Like 2A | A. Water conservation; retrofit alternating SAS | A. Waterless toilets and existing gray-water systems |
| | B. Convey to treatment plant, disposal by rapid infiltration | B. Conveyance to communal SAS | B. Like 2B | B. Conveyance to common SAS | B. Conveyance to common SAS |
| | C. Convey to treatment outside area | C. Like 1c | C. Like 1c | C. Like 1c | C. Conveyance to package plant and land application |
| | | | | | D. Like 1c |

## EXHIBIT 6.1

## ALTERNATIVES FOR PROBLEM AREAS (Cond.)

| PROBLEM AREA | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|
| PROBLEM AREA ALTERNATIVES | A. No action (none required now)<br>B. Conveyance to common SAS<br>C. Like 1C | A. Add common SAS; mounds for 4 houses<br>B. Connect 4 houses with small diameter sewers and pump<br>C. Like 1C | A. Like 5A<br>B. Mounds where possible; common SAS where required<br>C. Conveyance to common SAS<br>D. Like 1C | A. Like 4A<br>B. Conveyance to common SAS<br>C. Like 1C | A. Add common SAS for existing sewer<br>B. Further treatment and discharge<br>C. Like 1C |

## EXHIBIT 6.1

## ALTERNATIVES FOR PROBLEM AREAS

| PROBLEM AREA | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PROBLEM AREA ALTERNATIVES | A. Use compost toilets and existing systems for graywater to minimize extent of sewering; otherwise like B.<br>B. Convey to treatment plant, disposal by rapid infiltration<br>C. Convey to treatment outside area | A. Mounds where required<br>B. Conveyance to communal SAS<br>C. Like 1c | A. Like 2A<br>B. Like 2B<br>C. Like 1c | A. Water conservation; retrofit alternating SAS<br>B. Conveyance to common SAS<br>C. Like 1c | A. Waterless toilets and existing gray-water systems<br>B. Conveyance to common SAS<br>C. Conveyance to package plant and land application<br>D. Like 1c |

## EXHIBIT 6.2

## DECENTRALIZED COMMUNITY SYSTEM OPTIONS

| COMMUNITY-WIDE SYSTEM | | | | | |
|---|---|---|---|---|---|
| 1. Maximum On-Site | A | A | A | A | A |
| 2. On-site Communal #1 | A | B | B | B | B |
| 3. On-site Communal #2 | B | B | B | B | C |

### EXHIBIT 6.1

### ALTERNATIVES FOR PROBLEM AREAS (Cond.)

| PROBLEM AREA | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|
| PROBLEM AREA ALTERNATIVES | A. No action (none required now)<br>B. Conveyance to common SAS<br>C. Like 1C | A. Add common SAS; mounds for 4 houses<br>B. Connect 4 houses with small diameter sewers and pump<br>C. Like 1C | A. Like 5A<br>B. Mounds where possible; common SAS where required<br>C. Conveyance to common SAS<br>D. Like 1C | A. Like 4A<br>B. Conveyance to common SAS<br>C. Like 1C | A. Add common SAS for existing sewer<br>B. Further treatment and discharge<br>C. Like 1C |

### EXHIBIT 6.2

### DECENTRALIZED COMMUNITY SYSTEM OPTIONS (Cond.)

| COMMUNITY-WIDE SYSTEM | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|
| 1. Maximum On-Site | A | A | A | A | A |
| 2. On-site Communal #1 | B | A | B | B | A |
| 3. On-site Communal #2 | B | B | C | B | B |

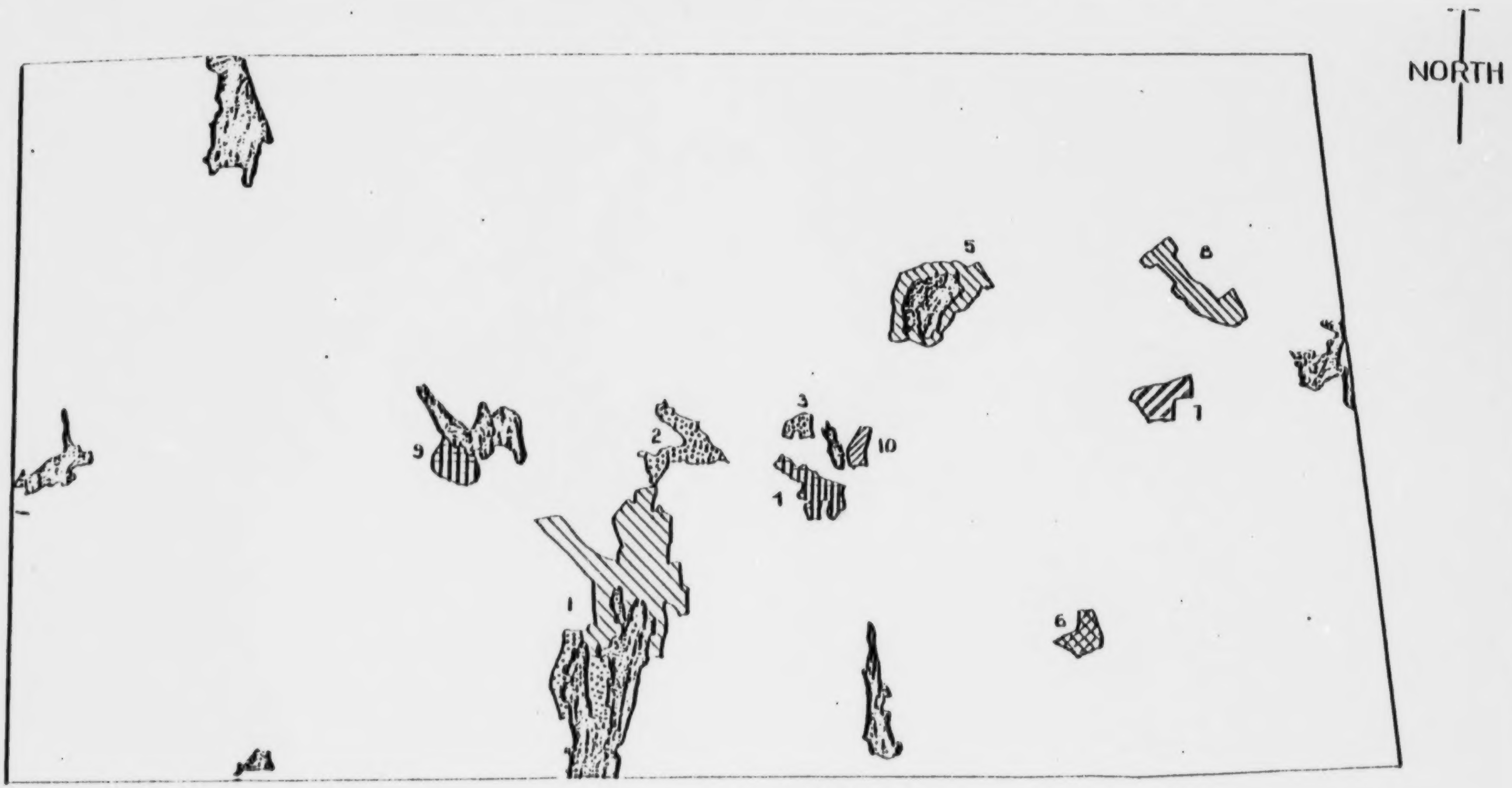
NORTH
1
1
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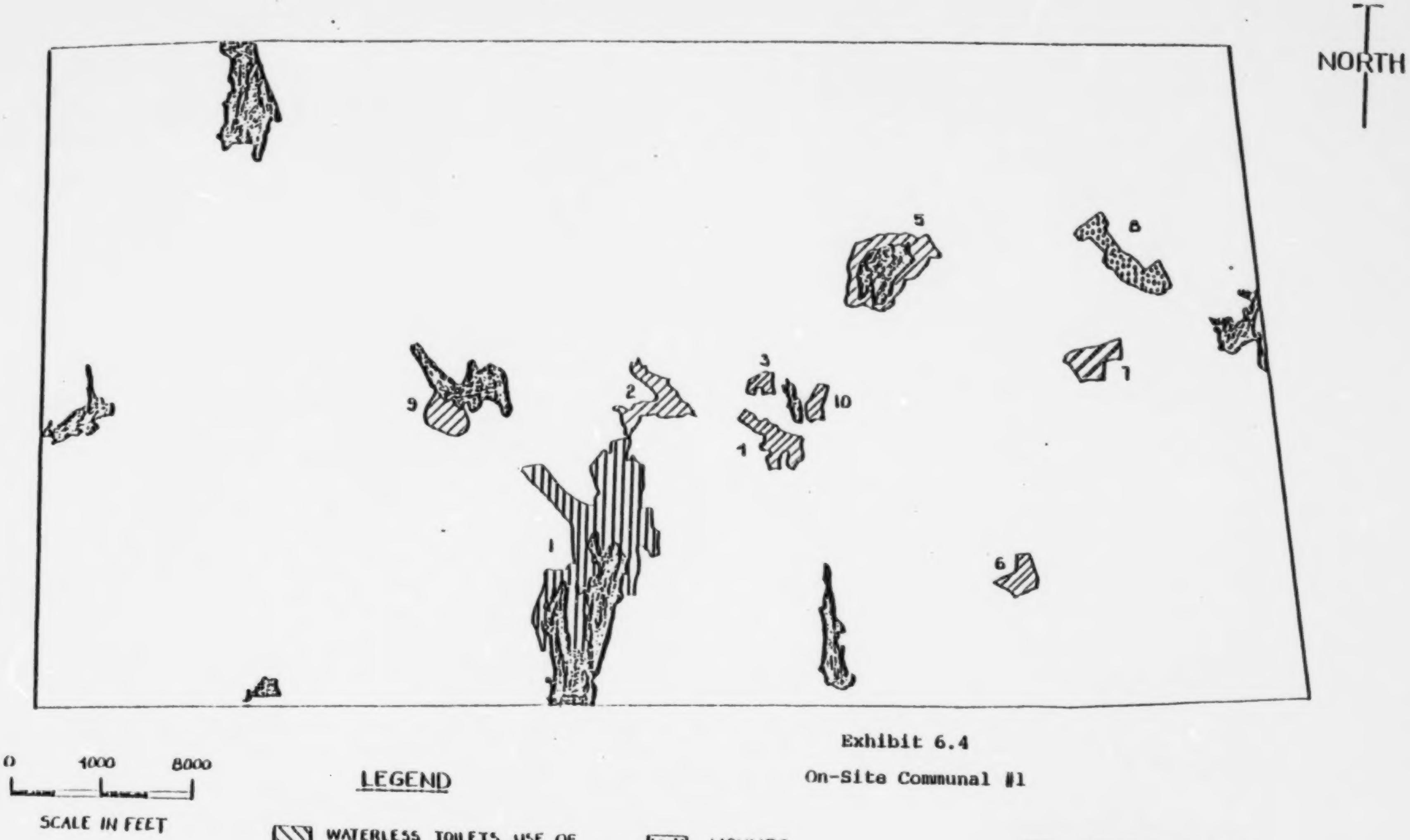
Exhibit 6.3

On-Site

0
4000
8000
SCALE IN FEET
LEGEND
▨ WATERLESS TOILETS, USE OF EXISTING SYSTEM FOR GREYWATER
▨ SEWER, COMMON DISPOSAL FIELD
▥ SEWER TO TREATMENT AND LAND DISPOSAL
▤ CONVEY OUT OF AREA
MOUNDS
WATER CONSERVATION DEVICES, ALTERNATING SAS
▦ MONITOR EXISTING SYSTEMS
▨ ADDITION OF COMMON SAS, FOR OUTLYING AREAS USE MOUNDS
▨ TREATMENT WITH SURFACE DISCHARGE
LARGE SCALE CONVEY
WATER BODIES
1. PROBLEM AREA IDENTIFICATION


NORTH
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SCALE IN FEET
1
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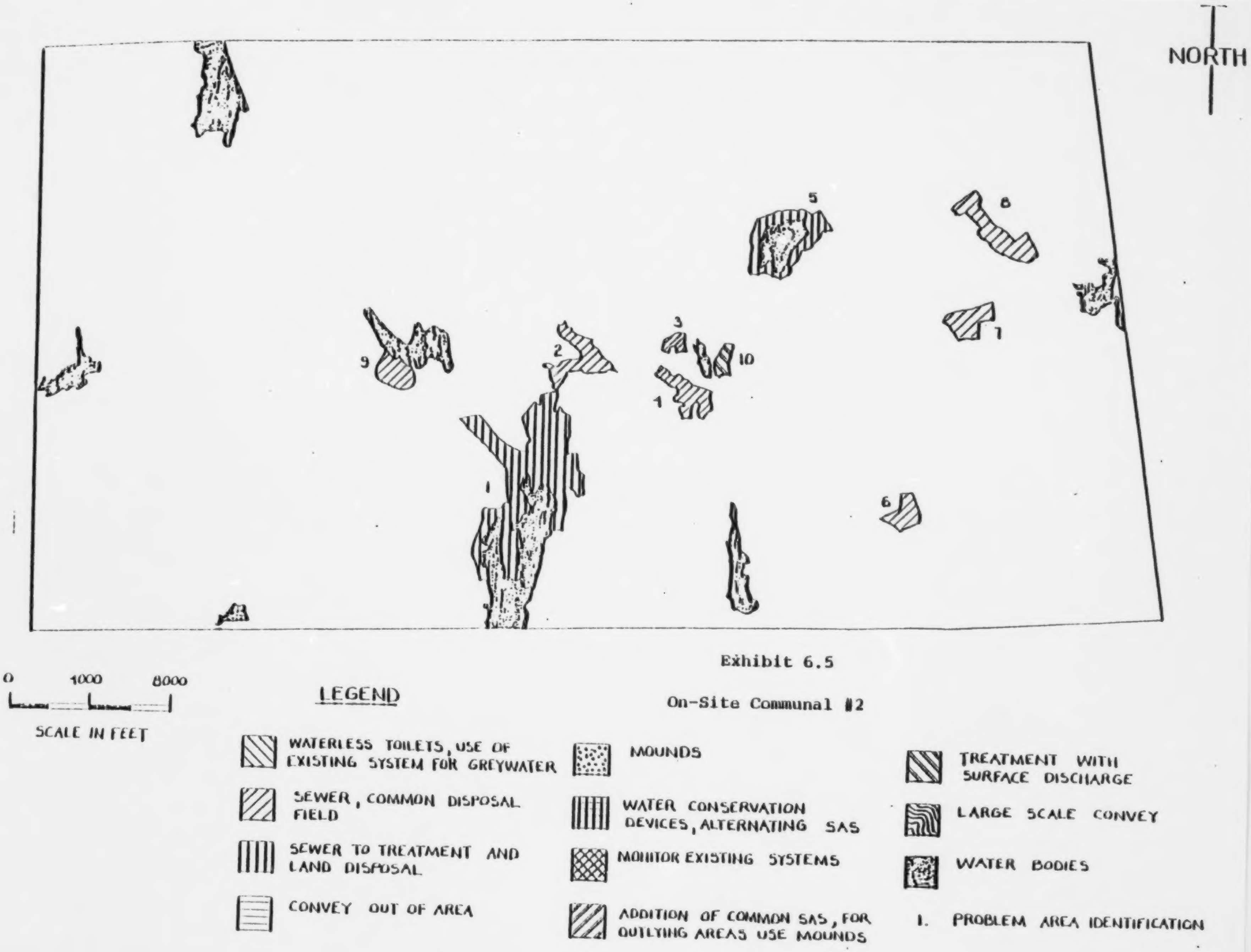
Exhibit 6.4

On-Site Communal #1

LEGEND
▨ WATERLESS TOILETS, USE OF EXISTING SYSTEM FOR GREYWATER
▨ SEWER, COMMON DISPOSAL FIELD
▥ SEWER TO TREATMENT AND LAND DISPOSAL
▤ CONVEY OUT OF AREA
▒ MOUNDS
▥ WATER CONSERVATION DEVICES, ALTERNATING SAS
▩ MONITOR EXISTING SYSTEMS
▨ ADDITION OF COMMON SAS, FOR OUTLYING AREAS USE MOUNDS
▨ TREATMENT WITH SURFACE DISCHARGE
▒ LARGE SCALE CONVEY
■ WATER BODIES
1. PROBLEM AREA IDENTIFICATION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SCALE IN FEET
LEGEND
▨ WATERLESS TOILETS, USE OF EXISTING SYSTEM FOR GREYWATER
▨ SEWER, COMMON DISPOSAL FIELD
▥ SEWER TO TREATMENT AND LAND DISPOSAL
▤ CONVEY OUT OF AREA
▒ MOUNDS
▥ WATER CONSERVATION DEVICES, ALTERNATING SAS
▩ MONITOR EXISTING SYSTEMS
▨ ADDITION OF COMMON SAS, FOR OUTLYING AREAS USE MOUNDS
▨ TREATMENT WITH SURFACE DISCHARGE
▒ LARGE SCALE CONVEY
▒ WATER BODIES
1. PROBLEM AREA IDENTIFICATION

Exhibit 6.5

On-Site Communal #2

## EXHIBIT 6.1

## ALTERNATIVES FOR PROBLEM AREAS

| PROBLEM AREA | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| PROBLEM AREA ALTERNATIVES | A. Use compost toilets and existing systems for graywater to minimize extent of sewering; otherwise like B.<br>B. Convey to treatment plant, disposal by rapid infiltration<br>C. Convey to treatment outside area | A. Mounds where required<br>B. Conveyance to communal SAS<br>C. Like 1c | A. Like 2A<br>B. Like 2B<br>C. Like 1c | A. Water conservation; retrofit alternating SAS<br>B. Conveyance to common SAS<br>C. Like 1c | A. Waterless toilets and existing gray-water systems<br>B. Conveyance to common SAS<br>C. Conveyance to package plant and land application<br>D. Like 1c |

## EXHIBIT 6.2

## DECENTRALIZED COMMUNITY SYSTEM OPTIONS

| | | | | | |
|---|---|---|---|---|---|
| COMMUNITY-WIDE SYSTEM | | | | | |
| 1. Maximum On-Site | A | A | A | A | A |
| 2. On-site Communal #1 | A | B | B | B | B |
| 3. On-site Communal #2 | B | B | B | B | C |

## EXHIBIT 6.6

## CENTRALIZED COMMUNITY SYSTEM OPTIONS

| | | | | | |
|---|---|---|---|---|---|
| 4. Centralized #1 | C | C | C | C | B |
| 5. Centralized #2 | C | C | C | C | D |
| 6. Maximum Centralized | C | C | C | C | D |

## EXHIBIT 6.1

## ALTERNATIVES FOR PROBLEM AREAS (Cond.)

| PROBLEM AREA | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|
| PROBLEM AREA ALTERNATIVES | A. No action (none required now)<br>B. Conveyance to common SAS<br>C. Like 1C | A. Add common SAS; mounds for 4 houses<br>B. Connect 4 houses with small diameter sewers and pump<br>C. Like 1C | A. Like 5A<br>B. Mounds where possible; common SAS where required<br>C. Conveyance to common SAS<br>D. Like 1C | A. Like 4A<br>B. Conveyance to common SAS<br>C. Like 1C | A. Add common SAS for existing sewer<br>B. Further treatment and discharge<br>C. Like 1C |

## EXHIBIT 6.2

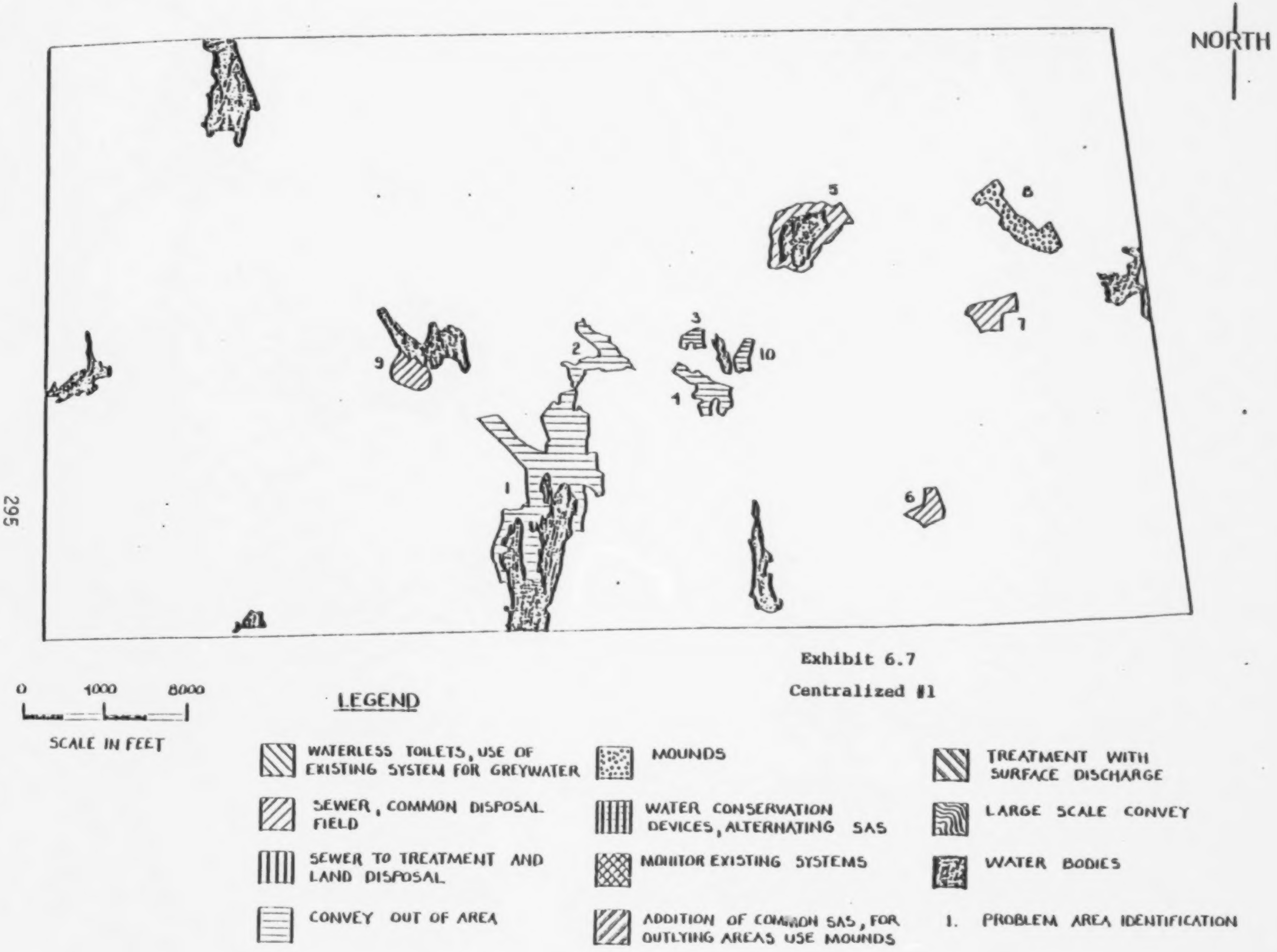
## DECENTRALIZED COMMUNITY SYSTEM OPTIONS (Cond.)

| COMMUNITY-WIDE SYSTEM | | | | | |
|---|---|---|---|---|---|
| 1. Maximum On-Site | A | A | A | A | A |
| 2. On-site Communal #1 | B | A | B | B | A |
| 3. On-site Communal #2 | B | B | C | B | B |

## EXHIBIT 6.6

## CENTRALIZED COMMUNITY SYSTEM OPTIONS (Cond.)

| | | | | | |
|---|---|---|---|---|---|
| 4. Centralized #1 | B | B | D | B | C |
| 5. Centralized #2 | B | B | B | B | C |
| 6. Maximum Centralized | C | C | D | C | C |



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SCALE IN FEET
LEGEND
WATERLESS TOILETS, USE OF EXISTING SYSTEM FOR GREYWATER
SEWER, COMMON DISPOSAL FIELD
SEWER TO TREATMENT AND LAND DISPOSAL
CONVEY OUT OF AREA
MOUNDS
WATER CONSERVATION DEVICES, ALTERNATING SAS
MONITOR EXISTING SYSTEMS
ADDITION OF COMMON SAS, FOR OUTLYING AREAS USE MOUNDS
TREATMENT WITH SURFACE DISCHARGE
LARGE SCALE CONVEY
WATER BODIES
1. PROBLEM AREA IDENTIFICATION

Exhibit 6.7

Centralized #1

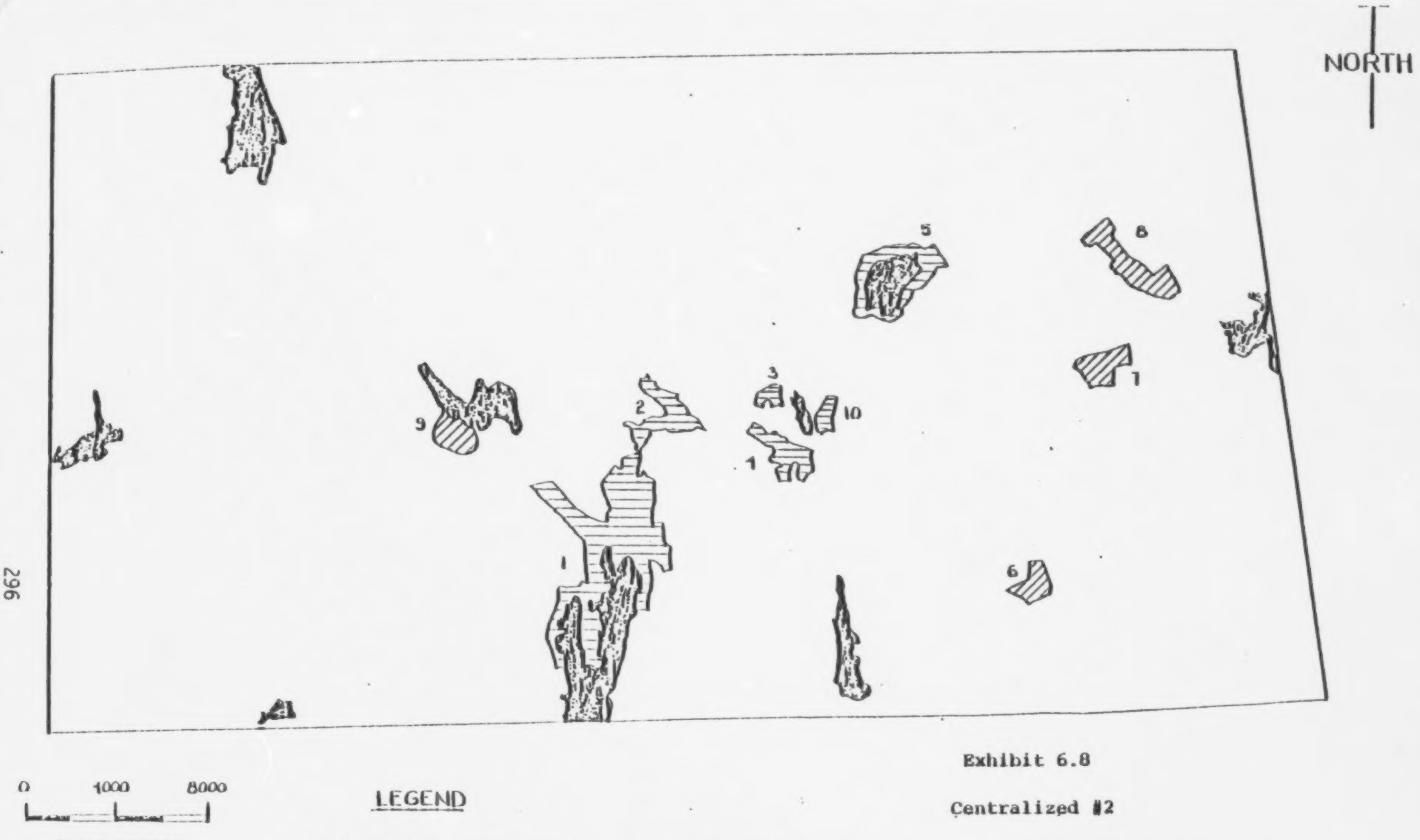

Exhibit 6.8

Centralized #2

LEGEND

- ▧ WATERLESS TOILETS, USE OF EXISTING SYSTEM FOR GREYWATER
- ▨ SEWER, COMMON DISPOSAL FIELD
- ▥ SEWER TO TREATMENT AND LAND DISPOSAL
- ▤ CONVEY OUT OF AREA
- ▒ MOUNDS
- ▥ WATER CONSERVATION DEVICES, ALTERNATING SAS
- ▩ MONITOR EXISTING SYSTEMS
- ▨ ADDITION OF COMMON SAS, FOR OUTLYING AREAS USE MOUNDS
- ▧ TREATMENT WITH SURFACE DISCHARGE
- ▒ LARGE SCALE CONVEY
- ▓ WATER BODIES
- 1. PROBLEM AREA IDENTIFICATION

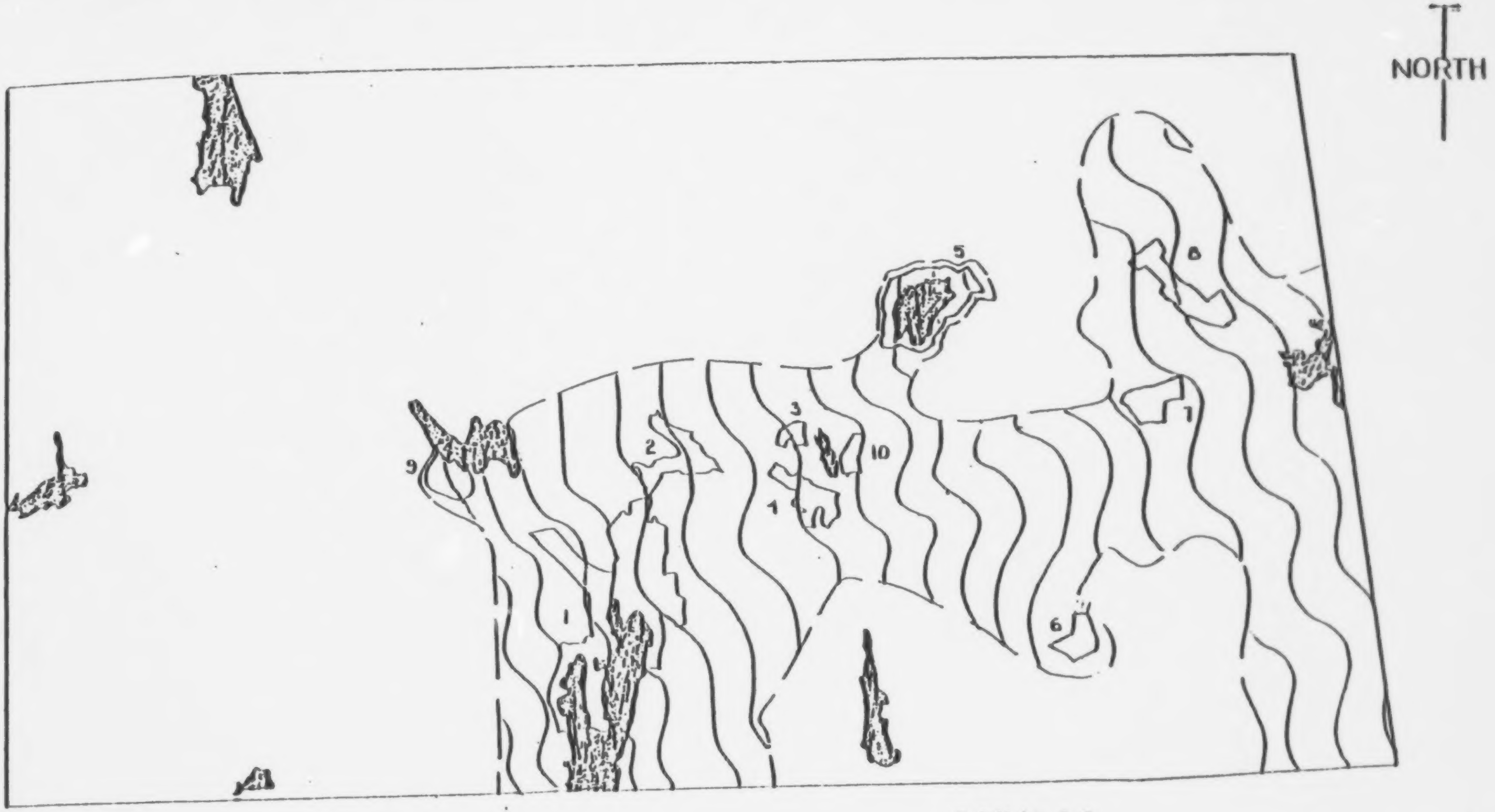
NORTH
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Exhibit 6.9

Large-Scale Conveyance

0
1000
8000
SCALE IN FEET
LEGEND
WATERLESS TOILETS, USE OF EXISTING SYSTEM FOR GREYWATER
SEWER, COMMON DISPOSAL FIELD
SEWER TO TREATMENT AND LAND DISPOSAL
CONVEY OUT OF AREA
MOUNDS
WATER CONSERVATION DEVICES, ALTERNATING SAS
MONITOR EXISTING SYSTEMS
ADDITION OF COMMON SAS, FOR OUTLYING AREAS USE MOUNDS
TREATMENT WITH SURFACE DISCHARGE
LARGE SCALE CONVEY
WATER BODIES
1. PROBLEM AREA IDENTIFICATION

actual system operations. These detailed compatibility questions need to be addressed for each system option, and can be answered best when the full option is defined. Another finding which needs to be made at this point is the location and technology for any centralized plants, but this is done in a similar manner.

In essence, then, the approach is to first generate community-wide systems, and then use the cases where the appropriate technologies are clear to redefine the options for the individual problem areas. This will allow maximum use of similar technologies.

## 6.3 GENERATION OF SLUDGE MANAGEMENT OPTIONS

Each of the technologies for wastewater management produces some amount of solids, and most require some sort of residuals management. Therefore, the next step is to choose residuals management options for each of the community-wide systems. Exhibit 6.10 shows a flow chart for such options, and the generation process should follow the steps discussed in Chapter 5. Exhibit 6.11 shows the community-wide systems for Atown, with sludge management options listed.

Since different treatment processes generate sludges with different characteristics, this step will take technical knowledge of the workings of various sludge processing methods, and may require some revision of the community-wide systems for compatibility.

## 6.4 DEVELOPMENT OF MANAGEMENT APPROACHES

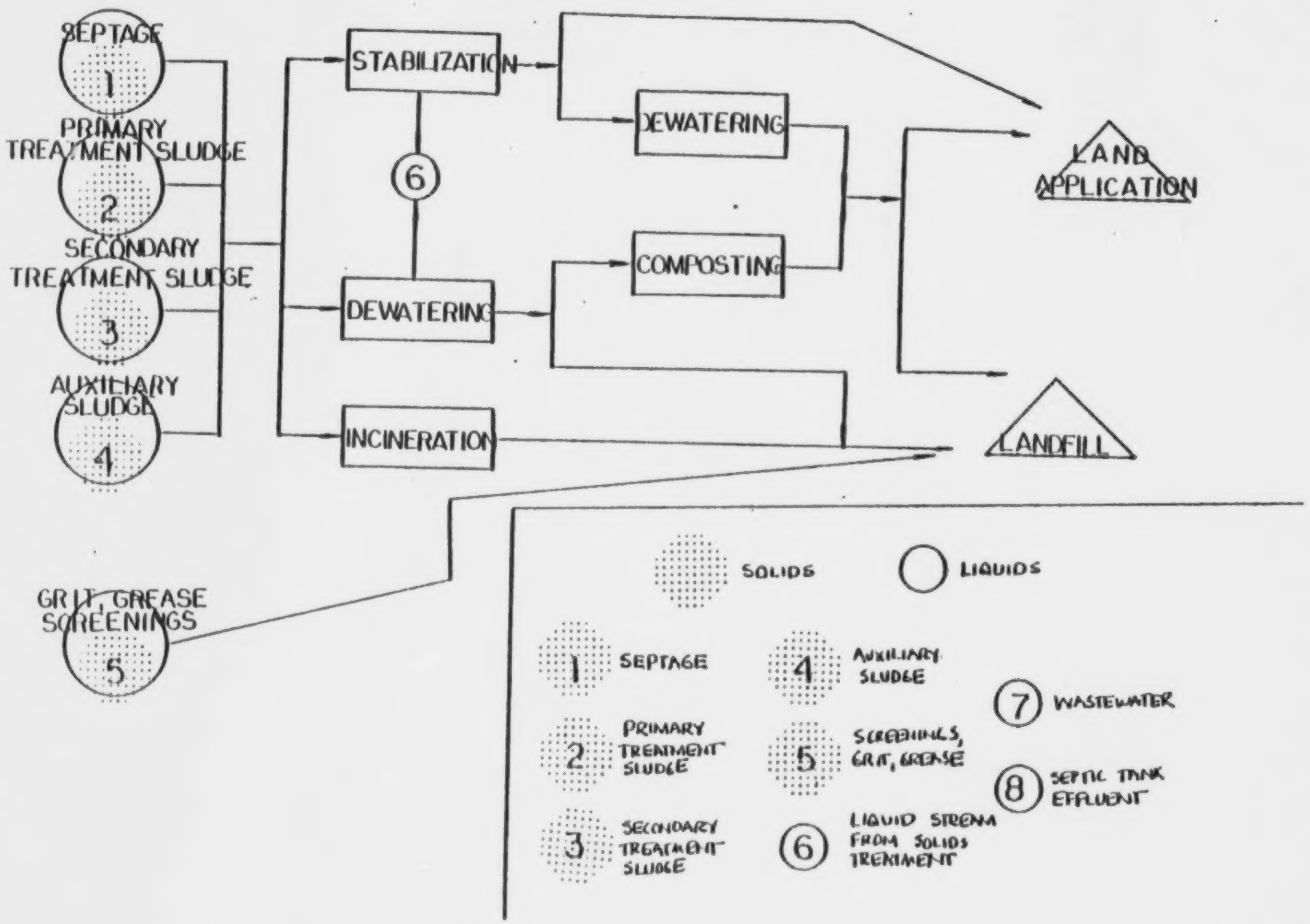
One of the axioms at the basis of this approach is that any wastewater system requires management. This is true for treatment plants just as it is true for conventional or alternative on-site systems. Therefore, it is necessary to develop a list of management requirements for every community-wide alternative. In Atown, there were essentially two options:

- private ownership of on-site and communal systems, with operating permits issued by the town

CHART 3

## EXHIBIT 6.10

## PROCESS TRAINS FOR RESIDUALS


SEPTAGE
1
PRIMARY TREATMENT SLUDGE
2
SECONDARY TREATMENT SLUDGE
3
AUXILIARY SLUDGE
4
GRIT, GREASE SCREENINGS
5
STABILIZATION
DEWATERING
INCINERATION
6
DEWATERING
COMPOSTING
LAND APPLICATION
LANDFILL
SOLIDS
LIQUIDS
1 SEPTAGE
2 PRIMARY TREATMENT SLUDGE
3 SECONDARY TREATMENT SLUDGE
4 AUXILIARY SLUDGE
5 SCREENINGS, GRIT, GREASE
6 LIQUID STREAM FROM SOLIDS TREATMENT
7 WASTEWATER
8 SEPTIC TANK EFFLUENT

## EXHIBIT 6.11

## RESIDUALS DISPOSAL OPTIONS

| Community-Wide System | Solids Management Options |
|---|---|
| 1. Maximum On-Site | a. landfill<br>b. subsurface injection |
| 2. On-Site/Communal #1 | a. landfill<br>b. treat septage; stabilize secondary sludge and septage solids to land<br>c. regional septage and sludge disposal |
| 3. On-Site/Communal #2 | a. like 2a, above<br>b. like 2b, above<br>c. like 2c, above<br>d. subsurface injection |
| 4. Centralized #1 | a. plant treats septage; secondary sludge dried and given away<br>b. plant treats septage; secondary sludge landfilled |
| 5. Centralized #2 | a. like 4a, above<br>b. like 4b, above |
| 6. Maximum Centralized | a. like 4a, above (minimal septage)<br>b. like 4b above (minimal septage) |

to ensure adequate maintenance.

- town management, including maintenance and rehabilitation for all systems where required.

We believe that these levels of management will allow the systems to be operated and maintained effectively, and will result in effective and environmentally sound wastewater management for all existing and new development in the town, which is the basic goal of the process.

This is the final step in defining a community-wide system which, in toto, consists of technical alternatives for individual problem areas (including, where appropriate, land use controls); residuals management options for the sludges resulting from treatment; and management, operations, and maintenance regulations and procedures. Evaluation and choice among these community-wide systems or modifications of them is the subject of the next section.

## 7.0 PROJECT EVALUATION AND RECOMMENDATIONS

At this point in the process, alternatives for the community-wide systems have been fully specified. The technologies are defined, sites have been chosen, and management structures have been proposed. All the proposed systems provide acceptable service to the residents and firms of the community, though they vary in their methods of doing so. For example, an individual home might be connected to a conventional sewer, to a STEP system with regular septic tank maintenance, or to a septic tank/ SAS, with regular maintenance plus replacement if the system fails at a later date. From the resident's viewpoint, the service is equal in all three: as desired, the wastewater is taken away and he doesn't have to do very much about it, except pay. Under the proposed systems, the wastewater is handled in an "environmentally sound manner."

Therefore, the basic question remains: Which system should be chosen? According to EPA regulations, each must be evaluated according to its cost-effectiveness, as well as its other impacts -- primarily environmental and socio-economic -- on the community. While we have not completed the cost-effectiveness analysis for any of our case studies as yet, the remaining sections of this chapter treat a number of overall project evaluation issues related to Step 1 planning for small communities. Section 7.1 describes the approach to environmental impact analysis, and Section 7.2 gives some suggestions for public participation based on recently proposed regulations, which may, of course, be changed before they become final. Section 7.3 then describes a number of issues related to cost-effectiveness analysis, and Section 7.4 discusses the potential for generating new alternatives at this step, and the making of recommendations.

### 7.1 Environmental Impact Analysis

There is little difference between environmental impact assessment for small comunity plans and for large ones. Major impacts are likely to be related to construction and to water quality effects of discharges, particularly to groundwater. Systems which depend strongly on land application or subsurface disposal are likely to have less obvious impacts on the receiving waters than systems using surface discharge, and will require more environmental assessment effort.

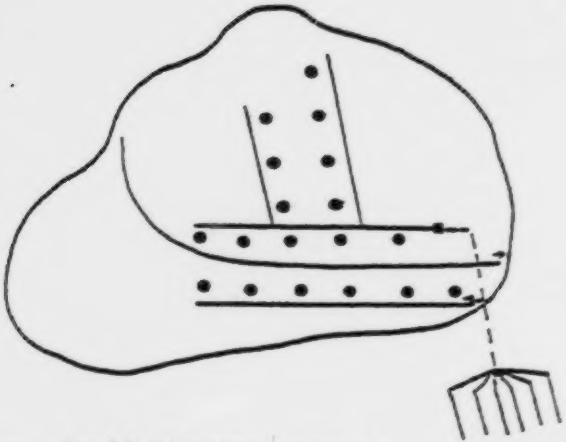
Secondary impacts, arising through land use change, are likely to be important for sewering alternatives and, in fact, for land use controls which act to limit development relying on on-site systems. Sewers may tend to attract growth to their service areas, while downzoning will tend to reduce growth. Alternatives such as pressure sewers, which can be built with limited excess capacity, may tend to preserve the status quo. In any case, the amount of growth anticipated for the undeveloped areas in the community should be estimated in the environmental assessment, particularly if an alternative would significantly change the development capacity. Exhibit 7.1 shows, for the hypothetical community, the reserve capacity in a specific problem area for new development, under various technology options. Preparation of such a map for the whole community for public participation is an important step, and community reaction to it may result in modifications in the proposed systems, with respect to the areas served.

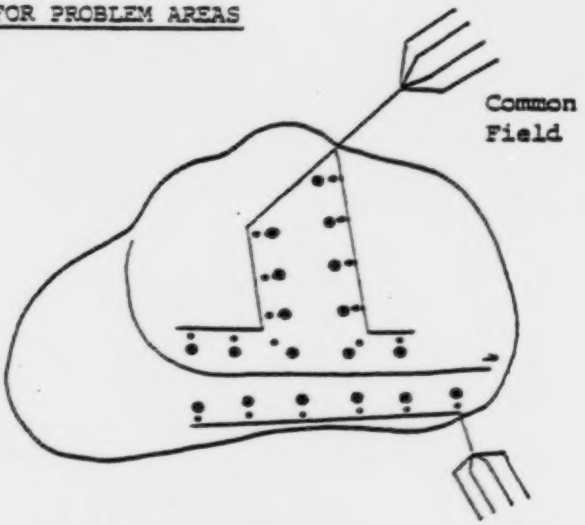
## 7.2 Public Participation

The Clean Water Act and its implementing regulations recommend a strong public participation program as part of facilities planning. In small communities, provisions of wastewater systems may also be a major topic of public interest among a diverse set of people. In addition, when a broad range of technologies are considered, issues such as aesthetics, maintenance requirements, and public perception may become extremely important in determining the success or failure of the proposed options, and should be considered. Property value change, monthly local costs, and

## EXHIBIT 7.1

## LAND USE IMPACTS FOR PROBLEM AREAS





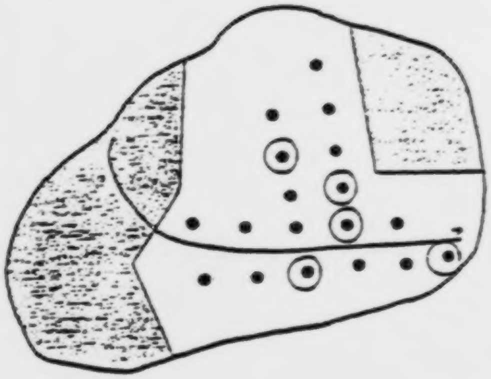
—— Small Diameter Sewer
--- Force main

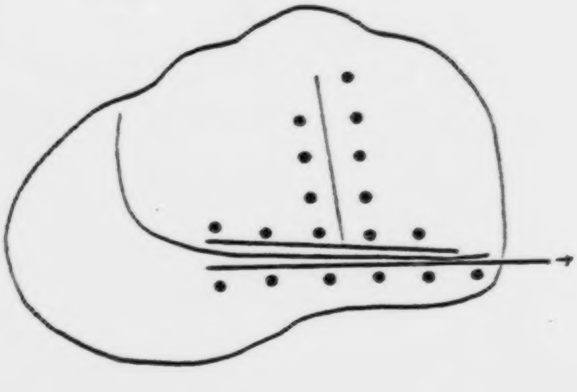
Capacity: 112 new households

—— STEP Pressure Sewers
• Individual Effluent Pumps

Common Field

Capacity: 125 new households





☐ Rezone to 1 unit per 80,000 sq. ft.

⊙ Rehab systems with serious problems install alternating fields

Capacity: 37 new households

Conventional gravity sewers connected to centralized plant

Capacity: 280 new households

requirements for maintenance easements or retrofit should be described as part of the alternatives evaluation.

While desired public participation will vary from place to place, it is likely that the engineer will work primarily with a town engineer or board of sewer commissioners, who are the client for the job.* We have assumed throughout that these local officials will be presented with project results at each major stage, for example:

- at the beginning of the project, when they can help identify data sources
- after preliminary problem area identification
- after field work and final problem area identification
- before alternatives for individual problem areas are finalized
- after the technologies are chosen for the community-wide systems
- before the cost-effectiveness and environmental evaluations
- after evaluation, but before the recommended plan is selected

It would also be useful, to have public meetings at various major points in the process, as an aid in the analysis. We recommend that there be three such meetings:

- after final problem area identification
- after alternatives are generated for the individual problem areas
- after alternatives are generated for the community-wide systems

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*If they are, for example, county officials, it would probably also be desirable to appoint one or more local representatives to also monitor the work.

In addition, a public hearing must, of course, be held on the final plan. The first public meeting will involve presentation to the community of the results of problem area identification and fieldwork, and thus will present the consultant's decisions on which areas are currently receiving inadequate service, and why. This is likely to be a controversial subject, and that is the major reason for a well-publicized open meeting.

In the second meeting, the engineer will present technological alternatives under consideration for various problem areas; again, the technologies being considered may be controversial, and public opinions about subjects ranging from sewers to waterless toilets or water conservation may be instructive on which types of systems could eventually be implemented.

In the third meeting, the engineer will present the complete alternatives prepared for evaluation, with site locations for centralized plants and sludge management, decisions about which areas will be served with what types of systems, and descriptions of management procedures and regulations (e.g., septic tank installation and pumping rules). The major reason for the meeting is to keep the public informed; this is also the last opportunity for modifying the systems before detailed evaluation.

Finally, the public hearing will present the results of that evaluation, and the final recommendation based on cost-effectiveness and other reasons. This hearing on the plan is required by law and is also the point where financial issues and local charges can be discussed in detail.

A public involvement program such as this would, ideally, require mailings to community residents, newspaper stories (not just "legal notices"), and other approaches to get the community involved. While the proposed program may be more extensive than necessary in some places, the plan should, to the extent possible, represent the needs and preferences of the community, and public involvement is one of the available approaches for assessing their perceived needs and preferences for technologies and management structures.

This program fits well with the "Basic Program" being defined by the Public Participation Task Force of EPA, for the Clean Water Act.* That program suggests "consultation" with the public when current and future needs are identified, and when alternatives are being defined (meetings 1-2 of our program). The public meeting is suggested for a time when alternatives have been largely developed, but a recommendation is not yet made (our third meeting), and the public hearing is scheduled on the recommended plan, as we have also proposed. In essence, we have modified this program for a small community by suggesting that public meetings are the most efficient way to involve the public, with advisory committees and so forth likely to be unnecessary in areas with limited population.

The task force proposals require more extensive involvement in a number of situations, such as the following:

- a significant change in land use
- a significant increase in plant or interceptor capacity
- substantial cost to users
- a new treatment plant
- a significant increase in sewered area
- a significant adverse impact on environmentally-sensitive areas
- multi-community systems
- significant general public controversy
- significant impact on local population growth
- significant impact on local economic growth

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*Regulations were proposed August 7, 1978.

"Significant" and "substantial" are to be determined by the Regional Administrator, so that these situations are generally unlikely to affect small communities. Under the proposals, the main result would be increased requirements for notice and for responsiveness to public comments.

## 7.3 Cost-Effectiveness Analysis Issues

At this point, the cost-effectiveness analysis has not been completed for any of the case studies. Under the construction grants regulations, this analysis determines which system should be chosen for a community (or, at least, which is eligible for Federal grants, and in what amount). Therefore, all costs for the proposed systems should be considered, and they should be considered on an equivalent basis. This section describes a number of issues which must be considered in performing, and reviewing, cost-effectiveness analysis for small communities with technologies such as those considered throughout this document. While the list is not exhaustive, it does provide some information on the sorts of things that are likely to come up, and some suggested solutions.

Analysis of Incomplete Systems: One of the easiest ways to bias an analysis against on-site alternatives is to consider the full on-site system in the costing, but to start counting sewer costs at the street. The house connection can be extremely expensive in some cases, and should be considered as part of the wastewater management system. The suggestion in the regulations that "alternative" starts, in essence, at the base of the toilet, should be applied to conventional systems as well, in comparing costs.

Another way of analyzing incomplete systems is to analyze one system (e.g., a sewer) for its service area, while analyzing another (e.g., a septic tank maintenance program) for the community as a whole. The latter may serve more sites, and thus incur higher costs. It is our view that management is required for the community as a whole, and that all costs should be included, even such things as paying for private pumpers. By requiring that all systems are costed for the entire area, the costs can be consistently compared, and will not be biased towards the more-limited options.

Design Lives: The salvage value evaluations, and the other portions of the cost analysis, require that design lives be estimated for the various technological options. For on-site systems, however, these design lives are difficult to estimate, since there is limited experience with them in-place. We have assumed 20 years for the design life of new on-site systems, but have also assumed that existing systems will continue to operate with the current failure rate.

Therefore, an aerobic system installed under the plan would be assumed to last 20 years for the cost-effectiveness analysis. Similarly, in an area served with existing septic tanks, if 2% currently required major rehabilition and new leaching fields each year, we would assume that 2% would require rehab each year over the design period.

Certain technologies have known design lives which are relatively short:for example the pumps on pressure sewers. We have assumed, though, that the piping for pressure sewers will last the same time as the pipes for conventional sewers, and we make this sort of assumption uniformly. Where there is limited other information, then, we attempt to make reasonable assumptions about design lives, and we suggest that the facility planners point out these assumptions in a table, for comment by reviewers in the community, and at state agencies and EPA.

Time-staging: Delaying (and discounting) future investments can reduce the cost of systems. This is desirable in many cases; for example, in Atown, there was a trailer park with subsurface disposal on very small lots. In the problem area identification phase, it became apparent that it would probably be only a matter of time before failures became common in this area, and systems would need to be installed, so the community systems include suggestions for this area.

However, no action is required now, and it may not be necessary to do anything for 10 years or so. Therefore, this phase of the overall project is suggested for later implementation.

Phasing of projects is suggested for study in the cost-effectiveness analysis guidelines, and we agree that it should be studied in the particular cases. However, it can bring about some problems in evaluation, particularly when different systems are staged differently. Assume, for example, that the options are to build a collection system and treatment plant, or to set-up an on-site management district, and assume (for the moment) that the on-site district was slightly cheaper. By phasing the collection system, and assuming that the areas to be served would require nothing while they awaited sewer construction, it might be possible to make the sewer system falsely appear cheaper.

This is just another example of incomplete analysis: actually, the areas which were planned to receive sewers in 10 or 15 years would need some sort of management system in the interim, and ignoring the costs of such a system would simply bias the analysis in their favor. The complete systems to be compared should not only provide service to all households in the community, but provide such service for the full 20-year planning period. Staging plans can save a great deal of money, but they do not make problems go away, and the costs of meeting those problems while waiting for the staged investment should be considered.

Treatment of Future Development: The procedures proposed for facility planning do not consider future development in much detail, aside from the secondary impact evaluation in the environmental reviews, and the standard procedures for projecting populations and flows. If we knew where all new houses were going to go, of course, we could design a cheaper system than we can when we are unsure about future development patterns. However, aside from the attraction that sewers have for new development, there is little that can be said about the optimal service areas for sewer systems or other alternatives twenty years from now. The public participation, and the expert judgment of community planners or other officials, may provide some guidance to the sorts of service which may be desirable in particular undeveloped areas, but the major concern is the service of existing problems, and new development will, to some extent, be an afterthought.

The biggest problem with respect to new development is that EPA has not determined projection periods to be used in sizing technologies such as pressure sewers, and has assumed that excess capacity for growth is not an issue in analyzing septic tanks. For the cost-effectiveness analysis in the case studies, we plan to use a consistent population projection for all system capacity measurements, and assume (where capacity is not available in the proposed collection and/or treatment systems) that new development will proceed wholely with on-site technologies. The assumption, in essence, is that (for costing purposes only) new growth will provide for itself by the cheapest available method: connection to existing treatment if available, or use of the least expensive on-site technology (usually septic tank/SAS)

Limits of the 20-year Planning Period: The 20-year planning horizon causes some distortions in the analysis, though they are likely to be minor in most cases. One distortion, already considered in the evaluation procedures, is that capital facilities may last longer than 20 years. This is the reason for the "salvage value" term: while nobody expects that sewers will, for example, be dug up and sold after 20 years, they clearly continue to have some value to the community. It would bias the analysis to assume that they depreciated fully in the 20-year period.

In comparing projects, though, the same problem exists with operation and maintenance costs. One system (e.g., a pond) may have lower O&M costs over its full life than another (e.g., an activated sludge plant). Differences in costs which occur after the 20 year period, though, are not considered according to the EPA plan.

Take two plants, one with capital costs of $1 million, and another with capital costs of $1.2 million, and with O&M costs of $50,000 per year, and $32,000 per year, respectively. Assuming straight line salvage value, and a discount rate of 7%, these two plants are equal over the 20 year period in cost-effectiveness. However, both plants are expected to last 25 years; over that period, the plant with higher capital and lower O&M is superior by 0.5% in present value, and should be chosen; differences in O&M cost in the last five years make a difference in the overall present value, even though that difference is small.

In this example, of course, this is a minor quibble. It only becomes important for items which are expected to last a long time, such as sewers, and for projects where some of the major portions are phased, but with construction 10-15 years out, and with O&M continuing beyond that. In other words, the cost-effectiveness analysis should be concerned with O&M costs beyond 20 years in the same situations where salvage value of capital is likely to be significant: for long-lasting investments, and for projects which are built late in the planning period.

Ownership Issues: The basic cost-effectiveness analysis for conventional systems splits costs into Grant eligible and ineligible, with the ineligible costs borne by the local government along with a portion of the eligible costs. In the case studies, costs will be broken down one step further, into public and private, with user charges computed for the local public costs, and with estimates made of the private costs. Therefore, if the system requires septic tank maintenance with private pumping every three years, we include an estimate of the average annual pumping costs in the presentation. House connection costs for sewers are to be handled similarly, with estimates of how much they are likely to vary, as are estimates of septic system rehabilitation, and the probability of systems requiring rehab over the period. In total, then, the presentation to the community might include a table such as Exhibit 7-2.

Alternative and Innovative Systems, and Set-Asides: In the rural states, most communities will probably try to qualify for the "alternative" or "innovative" categories, and get the set-asides. However, aside from the decision rules about which system should be chosen, this should not affect the cost-effectiveness analysis too much, and will not be discussed in detail here.

One caution should be mentioned, which is that EPA appears to be taking responsibility for systems which qualify as alternative or innovative, but which fail in practice. This should, obviously, be a concern in review, and there are no specific procedures in the cost-effectiveness analysis for weighing comparative risks of various technologies, aside from eliminating them as unacceptable. This is a serious problem, and one without any easy solutions, given the current structure of the evaluation procedure.

Conflicts Between Cost-Effectiveness and Community Preferences: Standard procedure has been to provide grant assistance only for the most cost-effective alternative, except in very special cases. With the implementation of the Clean Water Act, this procedure has been modified in two ways: in many cases, the community can build excess capacity it desires without losing its federal grant; and, alternative and innovative systems can be selected if they are no more than 15% more mostly than conventional systems.

However, if a community prefers to fund a land application system (qualifying as "alternative") that is 20%, or even 16% more expensive than a traditional system, it will not be able

EXHIBIT 7.2

## PER HOUSEHOLD COSTS TO RESIDENTS, 1990

| Sewered Households | Constant Dollars/Year |
|---|---|
| Public: User Charge | $ 85.00 |
| Private: House connection ($1000 at 6% over 20 years) | 87.18 |
| TOTAL | $172.18 |
| Non-Sewered Households | |
| Public: User charge (management and septage) | $ 12.00 |
| Private: Pumping @ $45 every three years | 15.00 |
| Rehab: $1500 each for the 2% of systems which fail each year | 30.00 |
| TOTAL | $ 57.00 |

to receive a grant for the project. It would have to either build the project selected by EPA, or fund the land application system locally, perhaps with some state assistance. There is no mechanism under the regulations for the EPA to give a grant of less than 75% for projects which are not the most cost-effective in the national analysis, even if the community is willing to pay the difference.

This sort of conflict is likely to occur in small communities, particularly when alternative and innovative technologies are being evaluated; it is likely to lead to significant problems in applying the current regulations.

## 7.4 Recommendations

Once the cost-effectiveness and environmental assessment efforts are complete, there are only two options available:

- make a recommendation; or,
- generate one or more new alternative(s)

If the recommended plan is not acceptable for some reason, or if the results of the analysis suggest that improved options could be developed, new or modified community-wide systems should be generated. It might, in some cases, be necessary to generate new alternatives for individual problem areas, but this depends on the particular situation. In some cases, more than one iteration may be required, with modifications done in an attempt to close in on the best system for the community.

However, in the end, a plan will be recommended to the community and included in the final step 1 plan. While design, construction, operation, and maintenance will still be required, this is the end of the major planning activity, and therefore forms the limits of our project.

From the reviewer's point of view, there are a number of aspects of concern. One is clearly community involvement: if the community has not been brought into the process through public meetings and other methods, it is unlikely that the system will receive long-term support; with alternative and innovative technologies, such support is likely to be critical. A second concern is that the problem areas have been identified correctly, and this should be documented in the plan. So should the evaluation, at least in passing, of a full range of alternatives for solving those problems; while some such material may be contained only in worksheets in the engineering firm, there should be evidence in the plan that conventional, alternative on-site, and alternative collection and treatment systems were at least considered, in situations where they might apply. Finally, the reviewer should be concerned with cost-effectiveness issues such as those mentioned above; small communities considering various systems are likely to have a number of difficult cost-effectiveness evaluation problems, and in some cases, these can have a major impact on which system is recommended.

# APPENDIX

## EXHIBIT A1 and A2

## SOCIO-ECONOMIC DATA REQUIREMENTS

Reproduced from best available copy.

| DATA SOURCE / DATA ELEMENT | U. S. CENSUS | STATE PLANNING AGENCY | STATE OFFICE OF EMPLOYMENT SECURITY | REGIONAL PLANNING AGENCY/208 AGENCY | LOCAL CENSUS | LOCAL ADMINISTRATOR | LOCAL TAX ASSESSOR | LOCAL CHAMBER OF COMMERCE | DATA USE |
|---|---|---|---|---|---|---|---|---|---|
| EXISTING POPULATION | | ○ | | | ● | | | | Existing Wastewater Flows |
| POPULATION AT CENNIAL AND DICENNIAL YEARS IF AVAILABLE FOR PAST 20 YEARS | ● | ● | | | | | | | Impact Assessment |
| POPULATION CHARACTERISTICS FOR LAST TWO FEDERAL CENSUS PERIODS--AGE COHORTS, MEDIAN FAMILY INCOME | ● | | | | | | | | Impact Assessment |
| POPULATION PROJECTIONS--LOCAL AND REGIONAL--FOR 25 YEAR PERIOD BY 5-YEAR INTERVALS | • | ○ | | ● | | | | | Future Wastewater Flows; Impact Assessment |
| LOCAL AND REGIONAL EMPLOYMENT BY MAJOR ECONOMIC SECTOR | | | ● | | | | | | Impact Assessment |
| EXISTING EMPLOYMENT FOR INDIVIDUAL BUSINESSES AND INSTITUTIONS | | | ○ | | | | | ● | Existing Wastewater Flows; Impact Assessment |
| ECONOMIC BASE/EMPLOYMENT PROJECTIONS FOR LOCALITY AND REGION | | | | ● | | | | ○ | Future Wastewater Flows; Impact Assessment |

● INDICATES PREFERRED DATA SOURCE.

○ INDICATES ALTERNATIVE DATA SOURCE.

• NOT NECESSARY, BUT SHOULD BE OBTAINED IF READILY ACCESSIBLE.

EXHIBIT A1 and A2 (Cont.)

SOCIO-ECONOMIC DATA REQUIREMENTS

| DATA ELEMENT / DATA SOURCES | U. S. CENSUS | STATE PLANNING AGENCY | STATE OFFICE OF EMPLOYMENT SECURITY | REGIONAL PLANNING AGENCY/208 AGENCY | LOCAL CENSUS | LOCAL ADMINISTRATOR | LOCAL TAX ASSESSOR | BUSINESS AND INSTITUTIONAL SURVEY | LOCAL CHAMBER OF COMMERCE | SEE TEXT | DATA USE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING PROPERTY ASSESSMENT VALUATION | | | | | | | ● | | | | Impact Assessment |
| PROPERTY TAX RATE | | | | | | | ● | | | | Impact Assessment |
| EQUALIZED TAX RATE | | | | | | | ● | | | | Impact Assessment |
| ANNUAL REVENUES BY MAJOR SOURCES | | | | | | ● | | | | | Impact Assessment |
| ANNUAL EXPENDITURES BY MAJOR SERVICE CATEGORIES | | | | | | ● | | | | | Impact Assessment |
| TOTAL DEBT AND NET DEBT | | | | | | ● | | | | | Impact Assessment |
| NET DEBT/CAPITA | | | | | | ● | | | | | Impact Assessment |
| BOND RATING | | | | | | ● | | | | | Impact Assessment |

● INDICATES PREFERRED DATA SOURCE.

○ INDICATES ALTERNATIVE DATA SOURCE.

* NOT NECESSARY, BUT SHOULD BE OBTAINED IF READILY ACCESSIBLE.

## EXHIBIT A3

## NATURAL AND PHYSICAL FEATURES DATA REQUIREMENTS

| | DATA SOURCE / DATA ELEMENT | National Weather Service | Local Airports | Local University | USGS | HUD | Soil Conservation Service | 208 Agency | State Division of Water Pollution Control | Other State Agencies | Local Tax Assessor | Local Water Department | Local Board of Health | DATA USE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLIMATE | Annual Precipitation | ● | ○ | ○ | | | | | | | | | | Alternative Screening |
| | Mean Temperature | ● | ○ | ○ | | | | | | | | | | * |
| | Temperature Ranges | ● | ○ | ○ | | | | | | | | | | * |
| | Humidity | ● | ○ | ○ | | | | | | | | | | * |
| | Prevailing Winds | ● | ○ | ○ | | | | | | | | | | * |
| | Evaporation | ● | ○ | ○ | | | | | | | | | | |
| Topography | | | | | ● | | | | | | | | | * |
| SOILS | Soils Limitation Maps | | | | | | ● | | | ○ | | | | Alternative Screening; Identification of Problems |
| | Interpretative Reports | | | | | | ● | | | ○ | | | | * |
| | Frost Depth | | | ○ | | | ● | | | ○ | | | | * |
| Wetlands | | | | | ● | | ● | | | ○ | | | | Future Growth Constraint |
| Flood Hazard Areas | | | | ○ | ● | ● | | ● | | ○ | | | | Future Growth Constraint; Siting of Alternatives |
| SURFACE WATER—STREAMS/RIVERS | Drainage Areas | | | | ● | | | | | | | | | Water Quality Impact Assessment |
| | Flow Characteristics | | | | ● | | | | ● | | | | | * |
| | Water Quality Data | | | | | | | | ● | | | ● | ● | * |
| | Existing Water Quality Classification | | | | | | | | ● | | | | | * |
| | Existing Uses of Water | | | | | | | ● | ● | | | ● | ○ | * |
| SURFACE WATER—PONDS/LAKES | Drainage Area | | | | ● | | | | | | | | | * |
| | Stream Sources | | | | ● | | | | | | | | | * |
| | Elevation | | | | ● | | | | | | | | | * |
| | Acreage | | | | ● | | | | | | | | | * |
| | Mean Depth | | | | | | ○ | ● | ● | | | ○ | | * |
| | Ownership | | | | | | | ● | | ○ | ● | | | * |
| | Water Quality Data | | | ○ | | | | ● | ● | | | ● | ○ | * |
| | Existing Water Quality Classification | | | | | | | ● | ● | | | | | * |
| | Existing Uses of Water | | | | | | | ● | ● | | | ● | ○ | * |
| GROUNDWATER | Areal Extent of Aquifers | | | | ● | | | | | | | | | * |
| | Groundwater Contours | | | | ● | | | | | ○ | | | | * |
| | Saturated Thickness* of Aquifers | | | | ● | | | | | ○ | | | | * |
| | Transmissivity* | | | | ● | | | | | ○ | | | | * |
| | Existing Public Wells | | | | | | | | | ○ | | ● | | * |
| | Average Daily Drawdown for Wells | | | | | | | | | ○ | | ● | | * |
| | Water Quality Data | | | ○ | ● | | | ○ | ○ | ○ | | ● | ○ | * |

● INDICATES PREFERRED DATA SOURCE

○ INDICATES ALTERNATIVE DATA SOURCE

* NOT NECESSARY, BUT SHOULD BE COLLECTED IF READILY AVAILABLE

## EXHIBIT A.4

## ADDITIONAL LAND USE DATA

| | DATA SOURCE<br>DATA ELEMENT | U. S. CENSUS | BUILDING INSPECTOR | TAX ASSESSOR | PLANNING BOARD ZONING BOARD | OFFICE OF STATE PLANNING | STATE HISTORIC PRESERVATION OFFICE | NATIONAL REGISTER | DATA USE |
|---|---|---|---|---|---|---|---|---|---|
| HOUSING | Local Building Permit Trends since Last Census | | ● | | | | | | Wastewater Flows |
| | # of Existing Units by type—SF, MF, Mobile, Seasonal | ● | ● | | | | | | Wastewater Flows |
| | Household Size | ● | | | | | | | Wastewater Flows |
| | % Owner/% Rentor | ● | | | | | | | Impact Assessment |
| | Median Valuation of Single Family | ○ | | ● | | | | | Impact Assessment |
| | Age of Housing Stock | ● | ● | | | | | | Problem Identification |
| LAND USE CONTROLS | Local Zoning—Uses allowed density requirements, special restriction | | ● | | ● | | | | Future Problem Identification |
| | Local Subdivision Regulations | | | | ● | | | | Future Problem Identification |
| | State Controls—Critical Areas Designation | | | | | ● | | | Future Problem Identification |
| HISTORIC & ARCHAEOLOGICAL | Historic, Cultural, Archaeological Sites, buildings, districts, structures and objects on the National Register | | | | | | ● | ● | Impact Assessment |

● INDICATES PREFERRED DATA SOURCE.

○ INDICATES ALTERNATIVE DATA SOURCE.

## EXHIBIT A.5

## PRELIMINARY REGULATORY CONSTRAINTS SCREENING MATRIX FOR COMMUNITY PROFILE

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| ISSUE / GOVERNMENT LEVEL | FEDERAL | STATE | LOCAL |
|---|---|---|---|
| Solids Disposal<br>-- Sludge and Septage | 1972 Marine Protection, Research, and Sanctuaries Act (P.L. 92-532) regulates ocean dumping of sludge.<br>Under 40 CFR 257, EPA is promulgating national criteria and standards for sanitary landfills; septage or sludge disposal to landfills from publicly-owned treatment works must be done in accordance with these criteria; new sites in "environmentally sensitive areas" must meet stringent criteria. | Many states have specific regulations regarding sludge and septage disposal on land.<br>All states regulate sanitary landfills and these regulations will, in many cases, deal with sludge and septage. | Local zoning may prohibit certain nuisance uses, such as solids disposal, in certain areas of the community. |
| Effluent Disposal<br>-- Surface Water Discharge | Under 40 CFR 35.917 of P.L. 92-500, EPA requires a minimum of secondary treatment for sanitary discharges in effluent limited segments. | Under Section 303(e) of P.L. 92-500, states have established stream classifications and waste load restrictions that affect direct discharges; in addition, states may have anti-degradation provisions in certain stream segments.<br>Through "critical areas legislation" or coastal zone management, some states can affect location of facilities. | Local zoning may prohibit certain nuisance facilities, such as treatment facilities; this may be a real constraint for package plants in certain neighborhoods. |
| Effluent Disposal<br>-- Land Application | Under the Safe Drinking Water Act, EPA may require that effluent disposal on the land in certain areas meet drinking water standards.<br>At a minimum under P.L. 92-500, land application technologies must meet best practicable waste treatment technology (BPWTT). | Under P.L. 92-500, states are developing minimum land application criteria.<br>State critical area regulations again may be used to prohibit certain sites. | Local zoning again may prohibit land application sites. |
| Effluent Disposal<br>-- Subsurface Disposal | Under the new 1977 Clean Water Act, individual systems funded by EPA must meet BPWTT.<br>1974 Safe Drinking Water Act may regulate community subsurface systems in "sole source aquifers." | Site sanitary code is the principal regulatory mechanism here; site feasibility, types of system allowable, size of systems -- all are regulated by the state. | Local codes may incorporate additional constraints in the sizing, type, and location of systems. |

EXHIBIT A.6

## EXISTING ON-SITE MANAGEMENT FUNCTIONAL RESPONSIBILITIES CHECKLIST

(A completed form is shown as an example)

| | MANAGEMENT ISSUE | RESPONSIBILITY | | | REQUIREMENTS/COMMENTS |
|---|---|---|---|---|---|
| | | Public | Private | Not Done | |
| DESIGN | Design Standards | ✓ | | | State Sanitation Code requirements incorporated into County Health Code; County has added requirements for alternating fields |
| | Design Engineer Licensing | ✓ | | | State requires that system designer be a licensed sanitary engineer or pass state certification test |
| | Site Feasibility Analysis | ✓ | ✓ | | County requires deep pit observation holes in addition to state mandated perc. test; also requires soils analysis for certain sites; site analysis witnessed by county sanitarian |
| PLANNING | Plan Review | ✓ | | | County sanitarian reviews final plans within 45 days as per state sanitation code; systems >15,000 gpd in size forwarded to District Environmental Health Office for review; detailed plan requirements—copy enclosed |
| | As-built Plan | | ✓ | | County requires as-built plan be filed with County Health Department prior to occupancy permit issuance |
| | Coordination with other local boards | ✓ | | | Building inspector occupancy permit contingent upon County Health Department ok; the building inspector also screens dwelling unit changes for additional on-site system requirements |
| INSTALLATION | Installer Registration | | | ✓ | |
| | Performance Bond | | ✓ | | County requires installer to file a $2,000 performance bond with County; refunded after satisfactory system operation for 365 days |
| | Excavation Inspection | | | ✓ | |
| | Leaching Field—Fill Inspection | | | ✓ | |
| | Leaching Field— Grade Inspection | | | ✓ | |
| | Backfilling Inspection | | | | County sanitarion inspects backfilling operation; 48 hour notice required. |
| OPERATION | Occupancy Permit | ✓ | | | County Health Department must sign off Building Inspector occupancy permit at each change of ownership in a dwelling unit. |
| | Public Education | ✓ | | | Brochure on appropriate user habits for on-site systems distributed at issuance of occupancy permit; also published semi-annually in local newspaper |
| MAINTENANCE | Pumping | | ✓ | | Occupany permit tied to a mandatory pumping of septic tank once every three years; notice mailed to occupant at appropriate time; pumpout receipt required to be mailed back within 40 days after pumping. |
| | Pumper Registration | ✓ | | | Private pumpers who serve homeowners are regulated by an annual registration form; required to return a copy of each form to county upon appropriate septage disposal |
| | Recordkeeping | ✓ | | | Through the occupancy permit renewal process and septage pumpout receipts, County is tracking performance of all systems; failures being correlated with user habits (through special survey) as-built plans and soils |
| MONITORING | Surface Water Quality Testing | | | ✓ | |
| | Groundwater Quality Testing | | | ✓ | |
| | Water Quality Monitoring | ✓ | | | County Sanitarian monitors nitrate levels for public wells that are in densely developed areas; water department conducts water quality analysis as per state requirements |
| ALTERATION | Repairs | ✓ | ✓ | | County regulates all repairs as if they were new installations; some regulatory process must be adhered to |
| | Dwelling Unit Conversions/ Enlargements | ✓ | | | County Building inspector notifies County Sanitarian of dwelling unit changes for possible additional on-site disposal requirements |
| FINANCING | Installation Fee | | ✓ | | County requires a $75 fee for reviewing design plans, witnessing site feasibility analysis, and witnessing installation |
| | User Charge | | ✓ | | County levies a $25 user charge for the renewal of all occupancy permits to cover administrative expenses |
| | Annual Appropriations | ✓ | | | Health Department receives an annual appropriation from the County general fund for department budget |

## WATER QUALITY IMPACT EVALUATION

Considerations of water quality for determining whether existing or proposed facilities are adequate or not.

- Surface Water -- In cases of surface water, there will be standards set by the 303e plans and the states;

- Ground Water — For soil absorption and all other land application systems there will be a need to evaluate the impact of systems on a case by case basis since standards have generally not been established;

  The engineer will be called on to estimate what these impacts will be and when they are likely to be important. The process will involve identifying whether or not the ground water needs to be protected and then estimating whether the proposed waste-treatment facilities can be accommodated.

We suggest the following categories for groundwater:

| Use | Type of Analysis |
|---|---|
| Unusable | None--any quality of waste discharge is acceptable |
| Potentially usable (but not being used) | 1. Determine potential uses<br>2. Examine for impacts of potential discharges |
| Private wells using watertable aquifer | 1. Screen using mass balance approach<br>2. If a problem is indicated, do more detailed work including borings to get hydrologic gradients and flows<br>3. Check adequacy of codes |
| Large wells using watertable aquifer | 1. Screen using the mass balance approach and existing water quality measurements<br>2. If a problem is indicated, do more detailed analysis |
| Groundwater flows to surface water (particularly impoundments) | 1. Check nutrient levels and trends in surface water bodies.<br>2. Based on soils tests, determine the estimated ability of soils to remove P |

| Use (continued) | | Type of Analysis (continued) |
|---|---|---|
| Groundwater flows (continued) | 3. | Where N is a concern, use the mass balance approach as conservative first cut. |

### The Mass-Balance Approach

This is a screening test based on a number of very simple assumptions about groundwater and infiltration. The simplest case comes when there is an unconfined aquifer with a potential nitrate problem, with leaching fields or other land application systems transporting nitrogen loads from wastewater. Assuming a maximum allowable concentration of 10 ppm $NO_3$-N in the aquifer, it is clear that if the average loads are less than 10 ppm, then the final concentration will be less than 10 ppm. The following assumptions can be made about the aquifer, and the sources:

- The only inflows to the aquifer are the wastewater loads and percolating rainfall;
- All nitrogen in the effluent reaches the aquifer;
- All nitrogen in the rainfall is removed by plant uptake;
- Percolation rates for rainfall depend on local development;
- There are no localized problems with drawdowns from wells;
- There is complete mixing in the aquifer.

Under these assumptions, a simple mass balance approach can be used. We require that the average concentration of nitrogen in all entering water be less than 10 ppm, so that the following equation holds:

$$\frac{\text{Wastewater N}}{\text{Total wastewater flow} + (\text{percolation rate}) \times (\text{total rainfall})} \leq 10 \text{ ppm}$$

All else being equal, development over the aquifer with septic tanks/SAS or other land application systems should be feasible if there is enough rainfall percolatng into the ground to dilute the nitrogen load sufficiently.

In essence, this equation acts as a limit on the density of development with septic tank/SAS: if houses are moved further apart, there will be more rainfall percolating per house, and a lower average nitrate load. Therefore, the equation is likely to be useful in establishing the acceptable density of development. Obvously, inclusion of groundwater movement, aquifer saturated thickness and related factors will require more analysis, and should only be done if a simple test such as this shows a potential problem to exist, or if there is trend data on increases in nitrate concentrations in the ground or surface waters in the area.

For surface water bodies which are fed by groundwater, the same sorts of analysis can be used, with a few complications:

- first, the phosphorus removal capacity of the soil should be tested, to see whether this is low enough to lead to potential problems in the planning period
- second, the concentration of nitrate that may lead to eutropication problems in a pond may be as low as 0.1 ppm, so the corresponding densities of interest may be much less
- finally, streambank vegetation may remove a great deal of the nitrogen load from groundwater, before the surface water bodies are affected

EXHIBIT A7

## GROUNDWATER DATA

The principal secondary sources of groundwater information have been devloped by the U.S.G.S. and are as follows:

- USGS Topographic Quadrangle Maps - These maps are important for groundwater information because they show surface water elevations. In some areas, surface water will be the surface expression of an unconfined aquifer. Also, in many areas, the water table aquifer will be highly related to the surface drainage pattern and the topographic maps can be used to delineate surface drainage patterns.

- USGS Geologic Quadrangle Maps (Surficial Geology) - These maps depict the extent and location of various types of unsolidated materials which occur surficially in an area. The present a planimetric view of the various types of deposits present at the surface of the study area. The planner should locate materilas, such as sand and gravel, on the map where porosity and permeability are favorable to the occurrence and availability of groundwater.

- USGS Basic Data Reports - Basic data reports are published by the USGS during their investigations of groundwater resources for given locations and/or river basin drainage areas. The reports include records and logs of selected wells and test holes, records of selected springs, and chemical analyses of water withdrawn from various wells, springs, and test holes. The information is presented in tabulated form recording the exploration numbers, locations, owner, year completed, elevations, depth, and water table data. Abbreviated logs of the explorations are presented where available. These logs describe the nature, depth, and thickness of materials found during exploration. Each exploration is numbered and located on a plan or map which is included in the report.

- USGS Hydrologic Atlases - Hydrologic Atlases are published periodically by the USGS to describe the availability of groundwater, stream flow characteristics, and water quality. A variety of maps and supportive texts may be provided. Those most often prepared include a surficial materials map area or river drainage basin, transmissivity map for the same area depicting the availability of water bearing formations to conduct groundwater, surface water data, usually including a variety of stream flow characteristics, showing the locations and potential yields from aquifers (favorability maps), the saturated thickness of unconsolidated materials, groundwater quality maps, and charts detailing concentrations of various elements in the water.

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EXHIBIT A.8

## REQUEST FOR INFORMATION ON WASTEWATER DISPOSAL

The information on this form will be strictly confidential. Specific information from this form will not be released for public review. Please complete as much of the questionnaire as possible and return using the pre-addressed, stamped envelope.

---

1. A) What type of wastewater disposal system do you have? ________ septic tank/leaching field ________ cesspool ________ discharge to surface water ________ other________ (Location of discharge: ________________________)

   B) When was the system installed?________________

2. Have you had any problems with your wastewater disposal system:

   ________ yes ________ no

IF YOU ANSWERED "NO" ON QUESTION #2, PLEASE SKIP QUESTIONS #3-8 AND CONTINUE WITH QUESTION #9.

3. If you answered yes to Question #2, please check the type of problem that best describes or described your situation. (Check more than one if necessary.)

   ________ slow drainage in sink and other water using appliance
   ________ odors outside
   ________ toilet sometimes backs-up
   ________ liquid is visible on the ground surface
   ________ other ________________________

4. How often do you have problems with your system?

   ________ weekly ________ monthly ________ frequently
   ________ other ________________________

5. When do you generally have problems? (Check more than one if appropriate).

   ________ spring ________ summer ________ fall ________ winter
   ________ after periods of frequent or heavy rainfall

6. If you still have a problem, how are you coping with it?

   ________ pumping
   how often? ________ weekly ________ monthly ________ winter
   cost of pumping ________
   ________ restricting water use
   describe ________________________
   ________________________________
   ________ repairing system
   ________ other
   describe ________________________
   ________________________________

7. If you had your system repaired, please answer the following questions.

When was it last done: ____________________________________________

What was done: ____________________________________________

____________________________________________________________

How much did it cost: ____________________________________________

Who did it? __________ private contractor __________ town __________ other

8. Have you had more than one major repair done on your system:

__________ yes __________ no

If yes, how many and when? ____________________________________________

____________________________________________________________

9. A) If you are not presently experiencing problems, how often do you have your system pumped:

__________ once a year __________ once every three years

__________ once every two years __________ never

__________ other ____________________________________________

B) How much does it cost? __________

10. Check the boxes appropriate to your house.

__________ dishwasher __________ garbage disposal

__________ washing machine connected to the disposal system

__________ washing machine not connected to the disposal system

11. When was your house built?

__________ 1970-1978 __________ 1960-1970 __________ 1950-1960

__________ 1940-1950 __________ 1900-1940 __________ before 1900

12. What is the approximate size of your house lot?

__________ less than 2500 sq. ft. __________ 15,000 - 20,000 sq. ft.

__________ 2500 - 5000 sq. ft. __________ 20,000 - 30,000 sq. ft.

__________ 5000 - 10,000 sq. ft. __________ 30,000 - 40,000 sq. ft.

__________ 10,000 - 15,000 sq. ft. __________ over 40,000 sq. ft.

13. How many people live in your household?

__________ total __________ number of children, 12-18 years old

__________ number of adults __________ number of other children

14. Is your house used on a year-round basis or seasonal basis?

__________ year-round __________ seasonal

If seasonal, what months is it occupied? ____________________________________________

15. A) Do any of your neighbors on your street have problems with wastewater disposal?

__________ yes __________ no

B) Why does it appear there is a problem?

__________ odor

__________ liquid is visible on the ground surface

__________ frequent pumping

__________ other (explain) ______________________________

______________________________________________

16. A) Do you fertilize your lawn annually?

__________ yes __________ no

B) Approximately how many pounds of fertilizer do you apply? ____________________

17. YOUR ADDRESS: ________________________________________

IF YOU DO NOT WISH TO GIVE YOUR ADDRESS, WHAT IS THE LOCATION OF YOUR HOUSE?

________________________________________ street

between ____________________________________ street

and ______________________________________ street

EXHIBIT A9

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## UNIT PROCESSES AND TECHNICAL OPTION

| | |
|---|---|
| **I. HOUSEHOLD GENERATION AND TREATMENT** | |
| 1) Greywater Use | greywater recycling |
| 2) Water Flush Toilets | standard toilets<br>water conserving toilets |
| 3) Waterless Toilets | composting toilets<br>incinerating toilets<br>oil flush toilets<br>biological toilets |
| 4) Water Conservation | water pressure reduction<br>low-flow shower heads<br>faucet controls<br>low flush toilets<br>insulation<br>water conservation appliances |
| 5) On-Site Treatment | septic tanks<br>aerobic systems<br>filtration and other greywater treatment methods |
| **II. TRANSPORT** | |
| 1) Septic Effluent | STEP pressure sewers<br>small diameter gravity sewer |
| 2) Raw Sewage Transport | conventional gravity sewers<br>grinder pressure sewers<br>vacuum sewer<br>hauling (holding tank and truck) |
| **III. CENTRALIZED TREATMENT** | |
| 1) Headwerks | grit chamber<br>bar screen<br>preaeration<br>prechlorination |
| 2) Primary Treatment | primary clarification<br>fine screening<br>comminution |

## UNIT PROCESSES AND TECHNICAL OPTION
(Continued)

| | |
|---|---|
| 3) Filtration | low rate or intermittent sand, mechanically cleaned high rate, pressure and upflow filters<br>recirculating sand filters<br>expanded bed biological filters |
| 4) Fixed Biomass | trickling filters<br>biodiscs |
| 5) Suspended Biomass | activated sludge (conventional and contact stabilization)<br>extended aeration<br>oxidation ditch<br>stabilization ponds |
| 6) Ponds | polishing ponds |
| 7) Anaerobic | septic/Imhof tanks<br>suspended biomass (biolytic tank)<br>fixed biomass (submerged filters and discs) |
| 8) Disinfection | chlorination<br>bromine<br>iodine<br>ultraviolet<br>ozone |
| IV. ON-SITE EFFLUENT DISPOSAL | |
| 1) Soil Adsorption Systems | conventional (leaching fields, trenches, chambers, pits)<br>dosing tanks<br>alternate fields<br>mounds |
| 2) Evapotranspiration | |
| 3) Surface Discharge | |
| 4) Filtration | recirculating sand and auxiliary treatment |
| V. CENTRALIZED EFFLUENT DISPOSAL (AND TREATMENT) | |
| 1) Disinfection | halogens<br>radiation<br>ozone |

## UNIT PROCESSES AND TECHNICAL OPTION
(Continued)

| | |
|---|---|
| 2) Land Disposal and Treatment | irrigation<br>low-rate and high-rate infiltration<br>soil adsorption<br>evaporation pond<br>overland flow |
| 3) Surface Water Disposal | |
| VI. SOLIDS TREATMENT AND DISPOSAL | |
| 1) Stabilization | incineration<br>chemical oxidation<br>chemical treatment<br>lagoon<br>aerobic/anaerobic treatment |
| 2) Dewatering | sand drying beds<br>settling<br>centrifugation<br>advanced technology |
| 3) Composting | |
| 4) Final Disposal | land spreading - food chain<br>land spreading - non-food chain<br>landfill |

## "GENERATING AND ANALYZING ALTERNATIVES"

Edited Questions and Answers Following Presentation
By James F. Hudson
Urban Systems Research and Engineering, Inc., Boston, Mass.

AUDIENCE: You mentioned calculation of the nitrate loading. What do you mean by it? In a community do you use net annual precipitation or just straight precipitation?

DR. HUDSON: For that one, we were doing it about as simple minded as we could get for use as a straight screening tool. We very simply took total precipitation that was infiltrating down toward the water table, total wastewater flow, and basically we were assuming no excess nitrogen in the fertilizer and all of the rainfall load was being pulled out by the surface vegetation. So that the nitrate load of interest was all that coming from the septic tanks. And we assumed that, again very simple assumptions, complete mixing, large aquifers but no other flows in or out. So if we could keep the net flow down from the surface below five PPMs, say, the ground water would probably be pretty safe long term. But that's about all we were doing.

AUDIENCE: On the system for the lake, was there any particular reason why you didn't look at a hybrid between a collection of the community systems and on-site systems? On a lot of lakes in Minnesota...maybe this isn't the case in New England, but in Minnesota you generally find between 40 and 60 percent of the lots are on good land and then a bunch of people built in the swamp where they shouldn't have. A hybrid system looks pretty good to us in a lot of cases. I was wondering why that wasn't considered as one of the options.

DR. HUDSON: No, it was not. No specific reason at this point. Over here, this one is about a 15-20 house sewer system to a septic tank to stream discharge; plus about four other houses that are right on the streambank. And there we did look at both trying to do something for those houses in trying to connect them in. And over here, we figured out there was only a small part of the area that was having any problems around that lake; so we were only looking at that one. But here, you're right. A hybrid could easily make sense. I suspect it's something that we'll be going back to at a later point after looking at the ones we've got. Now we're not saying that everything has to be done at first time through. I think that's important.

AUDIENCE: What we're proposing in New Hampshire is site approval in the step one process so that we don't get to the point where we've approved a step one when we don't realistically have a site. So we think it's very important that that's when the evaluation comes in.

AUDIENCE: We do that in Minnesota as well, not only with subsurface drain fields but with lagoons, particularly if you're looking at in place soils as the lagoon seal and also spray irrigation. We've got to know that if you're going to put a lagoon out there and seal it with clay that it's not a sand dune. You've really got to have some basic stuff before you even get into the step two.

AUDIENCE: You commented a couple times that you are looking for ways to simplify the facilities planning process with these alternative technologies. I sympathize with that and I hope you can do it. However, I think you should realize as I'm sure everybody here does that we're now looking at much more complex systems than we have been in the past. I don't think there's much simplification that's possible, I think we're going to have to do a lot more detailed work such as soils borings, evaluation of sludge handling, septage handling, land availability, community acceptance. This work is going to have to be done during the step one process so that when we get into the step two, we know we can go with what is in that plan and not have to start revising it again.

DR. HUDSON: Your cost of step one is going to go up. The question, it seems to me, is whether it's a factor of two or a factor of ten. And that's the fight that we're running.

AUDIENCE: I think in a lot of cases we've already done this with very small communities, let's say under 500 or even under 1,000. By the time you get done with the $50,000 or $100,000 facility plan and they're paying whatever their local share is, we've already told them, "Just go build the thing with non-union labor, make sure it's built correctly and get out of the grant program. You build it now with '78 dollars instead of '82 dollars and you'll be money ahead on that." I was wondering if EPA is going to be taking that position if you get into a situation like that.

MR. DEARTH: I don't see why EPA would really have anything to say about that.

AUDIENCE: You went through a schematic and I was wondering, how different is it from what we're supposed to be doing now? Where do you see the differences? Because the way it sounded, is that it's something that you developed and I'm wondering how you see it different than what was ideally happening, which is one thing; and what is actually happening which would be the second thing.

DR. HUDSON: Okay, that's a good question. One of our people at Urban Systems who is a political scientist looked at this. His response was, well, this is just a standard rational planning model, how everything is supposed to be done. And, he is perfectly right, and I think we all know that very seldom does real practice actually look like straight, as-scheduled-rational-planning. In terms of what's new about what we're doing, I would say what's new is getting more down into details and trying to lay it out. It looks to me fairly close to now whatever everybody gives the five steps and systems analysis or the steps in engineering design, or whatever. Get your data, figure out what your problem is, get more data where you need it, look at your options, evaluate them, reiterate a few times and now come to a decision. I'm sure we've all seen that, paradigm is probably the best word, enough times to feel that's got some value, at least as laying things out and that's all we've done.

Now, in comparison to actual practice, I would say that what we eventually come up with, is probably not going to add very much to the engineers and maybe the states and even regions that are really out in front in this sort of stuff and are getting good plans done, and getting quality work done all the way through the process. There are firms out there and states and so forth that it seems to me are doing that. Our hope is that if something like this is sitting with the project design manual or whatever, and an awful lot of engineering firms that it may bring up the ball game some. The poor plans, the ones that go in there, and either, well, I don't know about you folks, but I've seen a bunch where, now, they've claimed to have found existing septic tank problems, and in fact, when the state went back and looked at it, there were no problems. I've seen cases like that kind. Maybe by giving some ideas as to what good practice looks like, we can help a lot of those out, there are folks who are doing things pretty well already, we may give them a few ideas. That's my rating of what we are going to be adding to this.

AUDENCE: In line with that, EPA has out a Facility Planning Guide for Small Communities, it's a few years old now. Do you feel your work then will be changing that considerably, as to what we should be seeing in facility plans for small communities?

DR. HUDSON: I think what we're coming up with is, I'm sorry to say, it looks like it's a lot more extensive work. Because that means a lot more money for planning. Now, what we have all been seeing, I hope here is, that by doing that planning we may wind up saving more in the tail end. In the construction. You know, it's a trade-off, it's got to be looked at pretty closely and in various cases.

# INSTITUTIONAL CONSIDERATIONS IN IMPLEMENTING ON-SITE AND SMALL COMMUNITY WASTEWATER MANAGEMENT PROGRAMS

by

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# INSTITUTIONAL CONSIDERATIONS IN IMPLEMENTING ON-SITE AND SMALL COMMUNITY WASTEWATER MANAGEMENT PROGRAMS

## INTRODUCTION

Over the past few years Federal and state policies and regulations regarding on-site and small community (i.e., noncentral) wastewater systems have changed dramatically. At the national level, these changes are reflected in the 1977 Clean Water Act Amendments, (P.L. 95-217) in the most recent Environmental Protection Agency (EPA) memorandum (PRM 79-8), and in the newly formed "White House Rural Water and Sewer Initiatives." At the state level, state agency organizational changes, numerous state-sponsored workshops and conferences on noncentral wastewater management issues, and changes in state sewerage construction grant allocation policies have taken place which have helped to alter and refocus state responsibilities toward the management of on-site and small community systems. At the local level, the responsibility for managing, operating, and regulating on-site and small community systems has undergone equally dramatic changes over the past several years, with management responsibilities shifting from state to local levels, and new specialized wastewater management agencies and service districts being created.

The reasons for considering on-site and alternative systems can include:

- Existing On-Site Systems Failures
- Conventional Sewer System Being Too Costly
- Conventional Sewer System Having Unwanted Secondary Impacts

On-site and alternative systems are usually considered in the facilities planning process after existing systems have failed, or in new applications when conventional methods prove too costly. Such situations are becoming more and more common, especially in small community and rural applications. In these situations, a complete assessment of technical feasibility, performance reliability, total costs, and management requirements should be performed to determine if alternative systems are appropriate.

Without establishing effective management programs to assure proper planning, design, installation, and operation of on-site and alternative systems, adequate system performance will probably not be realized or maintained. Even properly designed and installed systems can and will fail due to misuse and/or insufficient attention. The relationships between different categories of system problems and specific contribution causes is shown by examples in Table 1.

This paper provides an overview of typical wastewater management program activities and participants at national, state, regional, and local levels and describes basic functions and approaches to designing management programs appropriate to small communities. Both public and private sector entities are identified as participants in the overall management of on-site and small community systems. The purposes of this management agency overview are to:

TABLE 1. PROBLEMS RELATED TO IMPROPER DESIGN, INSTALLATION OR OPERATION

| Problem | Contributing Causes |
|---|---|
| Overextended or Underutilized Central Collection Systems | • Lack of uniform sewer extension policy<br>• Inadequate consideration of viable treatment alternatives. |
| Immediate System Failure[1] | • Inadequate site evaluation.<br>• Inadequate system design.<br>• Improper installation practices. |
| Long-Term Failure[1] | • Failure to recognize marginal site limitations.<br>• Overloading systems beyond original design.<br>• Ignoring operation and maintenance requirements |
| Pollutional Impact[2] | • Inadequate site evaluation.<br>• Failure to consider regional water supply requirements.<br>• Failure to recognize cumulative impact of surrounding land use. |

[1] System failure refers to a situation causing the system to be unusable (e.g., sewage backup or surface breakout).

[2] Pollutional impact refers to contamination of groundwater or nearby surfacewater, not necessarily implying system failure as defined above.

1. Identify and examine the involvement of various agencies in the management process.

2. Highlight problems and constraints associated with the organization of the current management program structure that affect the performance and implementation of on-site and small community wastewater management program objectives.

3. Offer general observations, recommendations and guidance on how various management responsibilities can be provided by entities at the national, state, regional, and local levels.

The following sections of paper will describe the major activities which must be performed to carry out appropriate key management functions at the national, state, regional, and local level.

## DESCRIPTION OF ROLES AND RESPONSIBILITIES

This section describes some of the key functions carried out by agencies at the national, state, regional, and local level. Key management functions at each geographic level are identified and described with appropriate references to specific agency responsibilities.

### National Role

At the national level, activities by agencies to improve on-site and small community system management fall into four categories: grant assistance, planning, research, and technical assistance/information transfer. Since the passage of the Clean Water Act Amendments of 1977 (PL 95-217), Federal interest in the wastewater management problems of small communities has increased dramatically. Prior to enactment of the 1977 amendments, Federal water pollution control efforts were focused on conventional centralized collection and treatment facilities for large and medium sized communities. As these needs are being met, attention can be turned to the problems of smaller communities. The new amendments also recognize the need to give greater consideration to utilization of lower cost or more environmentally sensitive wastewater systems.

### Grant Assistance

The Clean Water Act of 1977 and subsequent regulations (PRM's 78-9 and 79-8) require greater consideration of on-site and alternative systems through the 201 Construction Grants Program. The major changes are summarized in Table 2. To encourage implementation of nonconventional systems, part of the construction grant fund has been set aside for alternative and innovative systems. In addition, some states are modifying 201 project priority lists to increase the number of fundable small community systems.

Step 1 Facility Plans for small communities must now do a more adequate analysis of existing system conditions, possible repair or replacement of existing systems, various configurations of alternative and conventional systems, and the relative cost-effectiveness of different schemes. The Clean Water Act and subsequent regulations and PRM outline a number of very specific requirements for an approvable on-site management system. The public agency which applies for Federal assistance must develop a user charge and cost recovery program, outline a program to assure proper operation and maintenance of the wastewater systems (including appropriate provisions to repair or replace deficient systems), and layout an adequate monitoring program to detect degradation of water wells and aquifers. Within these broad requirements, there is a great deal of flexibility regarding the approach which may be most appropriate, cost-effective, and acceptable to various communities. Approval of proposed management approaches rests with the EPA regional offices or those states with delegated facility review and approval responsibilities.

Although the EPA 201 Construction Grants Program is of primary importance, other Federal agencies may also provide funding for small community wastewater systems. Other programs for facilities construction include:

## TABLE 2

## CLEAN WATER ACT AMENDMENTS IMPACTING SMALL FLOWS

A set-aside of two percent for innovative and alternatives systems; 85% funding (as opposed to the usual 75% for capital costs of alternative technologies (Section 17; Section $202_A$).

A cost-effectiveness bonus of 15% for such technologies: That is, they can be 15% more costly and still be selected (Section 16; Section $201_J$).

A set-aside of up to 4% of the total grant amount for grants to rural areas (less than 3,500 population) implementing alternative technologies. The set-aside will be 4% in the states with 25% or higher rural population, and may be negotiated at up to 4% for states with lower rural populations (Section 27; Section $205_H$).

Creation of a clearinghouse for information on alternative technologies, to aid in technology transfer (Section 7; Section $104_Q$).

A requirement that such technologies be more systematically considered in the grants process, specifically in the facilities plans (Section 12 and Section 41; Section $201_G$ and 217).

Revised procedures for the evaluation of collection systems (see Section 36; Section 211).

Provisions making individual systems grant eligible for rehabilitation under certain conditions (Section 14; Section $201_H$).

Provisions to reduce water consumption and sewage flow (Section 21; Section $204_A$ and to study requirements for coordinating water supply and wastewater treatment (Section 72, Section 516).

Eligibility of alternative systems to serve existing private homes and businesses if public agency applies for grant, gives assurances of adequate maintenance, develops a monitoring program and initiates a user charge and cost recovery system (Section 14; Section $201_H$); publicly-owned alternative systems are also grant eligible.

1. Farmers Home Administration (FmHA), Department of Agriculture, "Water and Waste Disposal Systems for Rural Communities," (P.L. 92-419).
2. Department of Housing and Urban Development, "Community Development Block Grants - Discretionary," (PL 93-383).
3. Economic Development Administration, Department of Commerce, "Grants and Loans for Public Works and Development Facilities," (PL 89-136).

Some communities have met some personnel costs through participation in the Department of Labor's Comprehensive Employment and Training Act Program (CETA; PL 93-203).

According to the "White House Rural Development Initiatives," the Federal government will spend about $2.5 billion (in FY 1979) to help small communities construct or upgrade their water and sewer systems.

Planning

Wastewater facilities planning is an integral part of the 201 Construction Grants program just disucssed. Another important EPA planning program is the 208 areawide and state water quality management planning program. Increasing awareness of the needs of small communities, the appropriateness of alternative technologies, and alternative institutional and management arrangements is evident among 208 agencies. The 208 agency should be consulted early in the 201 Facilities Planning process for assistance in developing facilities and management strategies for small communities. The 208 agency may also provide assistance in implementing new managment arrangements and encouraging acceptance through public education programs.

Research

EPA's research on small community wastewater systems is centered within the Municipal Environmental Research Laboratory (MERL) in Cincinnati.

Current work involves:

1. A summary of the performance and cost characteristics of alternative on-site, cluster, and community systems.
2. An update and expansion of the Public Health Service Septic Tank Manual.
3. A methodology for conducting facility planning for small communities.
4. An evaluation of septage management practices.
5. Analysis of institutional arrangements for management of on-site and alternative wastewater systems.

Each of these projects will produce a manual available to 201 planners and engineers in 1980. These reports should assist in the production of more comprehensive facilities plans for small communities.

Other Federal research on small community wastewater technology is undertaken by the Farmers Home Administration, Forest Service, National Park Service, Housing and Urban Development Department, Office of Water Resources Technology (Department of Interior), and National Science Foundation.

### Technical Assistance/Information Transfer

Technical assistance (e.g., application assistance, plan review, referral, design, guidance, model codes) is available from EPA's 10 regional offices, Facility Requirements Division (Office of Water Programs Operations) in Washington, Water Planning Division (Office of Water Planning and Standards) in Washington, and MERL in Cincinnati. Available publications include those from MERL (i.e., Office of Research and Development), Water Planning Division (208 staff), Water Program Operations (201 program), and Technology Transfer. Seminars are held regularly to transfer research findings and program requirements. EPA has also provided funds to the University of West Virginia to operate a Small Flows Clearinghouse.

Publications and technical assistance are also available from other Federal agencies. These sources include the Farmers Home Administration, Forest Service, Soil Conservation Service, and Housing and Urban Development Department.

Various national organizations have been active in publishing reports and holding conferences on small community wastewater systems. These groups include the National Sanitation Foundation, National Environmental Health Association, National Association of Homebuilders, and American Society of Agricultural Engineers.

## State Role

State involvement in implementing on-site and small community wastewater management programs to a large extent parallels that of the Federal government by promulgating and enforcing regulations, and providing technical and financial assistance to individual communities. The concern for proper wastewater management has long been vested with state government, particularly with public health authorities, and more recently with water pollution control agencies, planning organizations, and other environmental management and regulatory agencies.

### Regulation/Enforcement

State public health authorities have traditionally been responsible for setting and enforcing standards. Some states have retained all regulatory authority over noncentral wastewater systems, while others have delegated all or part of the responsibility to local governments. Table 3 summarizes the regulatory approach toward on-site and small community systems regulation adopted by several states.

## TABLE 3

## SELECTED STATE WASTEWATER MANAGEMENT APPROACHES

| | On-Site Programs | | Small Community Programs | |
|---|---|---|---|---|
| | State/Local Institutional Arrangement | Program Approach[1] | State/Local Institutional Arrangement | Program Approach[2] |
| New Hampshire | State | TR & EN | State | SR |
| Illinois | State/Local | TR | State | FP |
| Maine | State/Local | TR & EN | State/Local | FP |
| Pennsylvania | State/Local | TR & EN | State/Local | FP |
| Washington | State/Local | TR | State/Local | COM |
| California | Local | ADM | State | EL |
| Vermont | Local | TR & EN | State/Local | FP |
| Maryland | Local | TR | State | EL |
| Minnesota | Local | TR & EN | State | COM |

[1] ADM-Administrative
TR-Technical review
TR & EN-Technical review and enforcement

[2] SR-Subdivision review only
EL-Enabling legislation only
FP-Facilities planning provisions
COM-Combination of programs

NOTE: Adapted from EPA Interim Report M-687, "Management of On-Site and Small Community Wastewater Systems", propared for EPA-MERL, Cincinnati by Roy F. Weston, Inc., November 1979

Public health laws and codes in states which share regulatory responsibilities with local governments are usually viewed as minimum standards to be adopted by local jurisdictions (which generally may establish regulations more restrictive than the state minimum). This regulatory arrangement can be structured in several ways. The most popular arrangement, as depicted in Table 3, is for local governments to review plans and issue permits for individual on-site systems, while the state retains the right to review and approve larger systems (and sometimes innovative and experimental systems as well). Under this shared arrangement some states, e.g., Wisconsin, reserve the right to review and approve subsurface wastewater disposal systems in subdivisions. The State of Washington exercises regulatory authority over multilot developments by requiring formation of a management agency to oversee maintenance and operation of subsurface wastewater disposal systems in subdivisions.

The State of New Hampshire is one state which has retained all regulatory authority over on-site and small community systems, and furthermore, has consolidated most functions dealing with subsurface wastewater disposal into a single agency, the New Hampshire Water Supply and Pollution Control Commission.

## Financing

The states (along with EPA regional offices) are responsible for administering the USEPA construction grants program. These funds are typically allocated via a priority list developed and maintained by a state water pollution control agency. (This state agency may not necessarily be the same state entity which regulates on-site systems, however.) The priority lists and state construction grants programs must now recognize the needs of rural communities, and investigate alternative technologies where appropriate.

The States of California and Wisconsin illustrate interesting state financing programs applicable to rural areas. The State of California Water Resources Control Board is using state monies to fund a portion of the operation and maintenance costs in three communities applying alternative systems. Wisconsin has recently created a state fund to finance the rehabilitation of failing industrial on-site systems. Under this financing program, individual homeowners may apply for loans through county health departments to correct failing systems.

## Technical Assistance/Public Education

As part of wastewater management programs in many states, certification and licensing of wastewater system designers and installers has provided needed technical guidance and education to both public and private sector entities. States like Illinois, Minnesota, and Pennsylvania have conducted training programs for system designers and installers for many years.

Complementary state education program activities include preparation and dissemination of technical manuals for wastewater system evaluation and design, and pamphlets outlining recommended homeowner maintenance practices for on-site systems. The technical manuals and pamphlets prepared by the Pennsylvania DER are noteworthy for their quality and comprehensiveness.

Financing community alternative wastewater management projects in California should also result in needed information on the actual costs of building, operating and maintaining these types of programs.

## Regional Role

Agencies operating at the regional level, i.e., at a multistate, multicounty, or multimunicipal basis, also have a major role to play in the management of on-site and small community systems. Types of agencies that operate at the regional level include:

1. Regional planning commissions
2. Regional sewer authorities, districts, or utilities
3. Interstate cooperatives
4. Watershed associations

These different types of agencies have been involved in planning, technical assistance/public education, and operation of noncentral systems.

### Planning

Regional planning commissions and watershed associations are examples of multimunicipal and multicounty entities that are involved in preparation of water quality management plans that, in many cases, address the need for noncentral system management programs. For the past several years, regional planning commissions in Vermont, New Hampshire, and Maine have been involved in preparing 201-type wastewater facilities plans for participating local governments through the statewide 208 areawide water quality management planning program. While these plans do not establish regulations or capital improvement projects to be adhered to by the member local governments, they do serve as a guide on common problems, such as developing model or prototype on-site management programs, regional septage management strategies, and model ordinances for regulating on-site wastewater systems siting and design.

Watershed associations, in the form of lake management districts, are popular in the States of Wisconsin, Minnesota, Michigan, and Maine. In Maine, for example, the Cobbossee Lake Watershed District Association was created to investigate areawide nonpoint water pollution problems and to develop and implement plans to abate such problems.

This multitownship organization has been conducting sanitary surveys of the lakeshore residences, and has been active in developing uniform procedures for siting and design of three subsurface systems within its jurisdiction.

### Technical Assistance

Interstate cooperatives, such as the Northwest States Task Force for On-Site Disposal (made up of Oregon, Idaho, Washington, Alaska, and the Province of British Columbia), and the Ten-State Standards Committee on Individual Sewage Systems of the Great Lakes - Upper Mississippi River Board of State Sanitary Engineers (represented by Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Wisconsin, and the Province of Ontario) are examples of regional entities involved in technical assistance. In addition, these cooperatives are involved in evaluating research, and developing criteria and standards for on-site systems.

### Operation and Maintenance

Regional sewer authorities have traditionally been involved in providing conventional sewerage services in urban and suburban areas. These entities have recently recognized their role in on-site and small community wastewater management by providing operation and maintenance services and septage treatment facilities to small communities. Examples of regional sewer agencies which are investigating opportunities for the management of noncentral systems include the Washington Suburban Sanitary Commission in the Washington, DC area, the St. Paul-Minneapolis (Minnesota) Metropolitan Council, and the Seattle (Washington) METRO. Generally, an entity with a broader jurisdictional base than a single town and more available technical resources and expertise, such as regional sewer utilities, may be better suited to provide operation and maintenance services because of economies of scale and efficiency than independently operated utilities.

## Local Role

Municipalities, towns, counties and special districts have traditionally been the primary focus (in conjunction with state and regional agencies) of on-site wastewater management programs. Management activities of local agencies include planning, regulation, operation, and technical assistance. In addition to these public agencies, on-site system designers, installers, septage haulers, and site evaluators are also involved in local wastewater management activities.

### Planning

The wastewater facility plan (e.g., the 201 Facility Plan), local comprehensive plan, and zoning map are principal tools of local government to guide the direction and character of future growth and wastewater management services within a community. The 201 Facility Planning Program, as mentioned before, requires that communities perform analyses of the condition of existing systems to determine the need for new facilities, as well as investigate alternative technologies, including noncentral wastewater systems.

### Regulation and Enforcement

Local governments are increasingly assuming the enforcement role in implementing on-site wastewater management programs. Typical local enforcement agencies include town health departments, county health departments, or special wastewater management districts (e.g., sanitary districts, soil and water conservation districts, and on-site management districts). Regulations are implemented by county and local health officers, district sanitarians, or certified "agents" of the state.

Illinois, California, Minnesota, Virginia, Maryland, and Washington are examples of states that have delegated much of their regulatory authority over individual systems to county health departments. In these states, the counties are free to develop more restrictive standards than the prescribed state minimum (except in California where there are no approved statewide minimum standards), and can develop staff and resource capabilities to implement on-site regulations. As mentioned earlier, in most state-local arrangements, the states usually delegate authority to regulate only small systems to local governments.)

The state-local arrangements formulated in Pennsylvania and Maine illustrate programs that place the enforcement role with the township and the private sector through state certified sewerage agents. These state-certified individuals are authorized to perform site evaluations, system designs, and installations. In Pennsylvania, the Sewage Enforcement Officer (SEO) is hired by the municipality (or the county) to evaluate site conditions, review and approve on-site system designs, and inspect the system installation. The SEO is certified by the state after taking qualification exams and attending training seminars.

Special management districts organized in California have also assumed authority for regulating system location and design, as well as supervising or providing maintenance. The Stinson Beach and Georgetown Divide, California, on-site management programs are examples of special approaches to approvals for system regulation.

### Technical Assistance/Public Education

As mentioned in the discussion of state technical assistance programs, manuals, brochures, and educational materials prepared by state agencies are important complements to local public education efforts to educate the public concerning design and maintenance of on-site systems. This can be done on a one-to-one basis at the local level, particularly through on-site management districts. The public education procedures of the Stinson Beach on-site management program offer a good approach to follow.

### Operation and Maintenance

In areas where physical conditions warrant a closer evalution of wastewater system design, installation, and operation, a wastewater management district may be established to direct and assume the supervision and enforcement roles. There are a growing number of special district programs organized on a communitywide or subdivision basis that provide continuous maintenance and monitoring of on-site and small community systems. Such management programs are administered by newly formed or preexisting sanitary districts, special management districts, public authorities, county and municipal public works agencies, as well as private entities such as homeowners associations, publicly-regulated utilities, rural cooperatives, and private installers/septage haulers.

These locally organized management programs can own, operate, and maintain noncentral wastewater systems, or can contract with individual homeowners to provide maintenance services.

## MANAGEMENT FUNCTIONS

To properly manage noncentral wastewater systems, an administration, operation, and implementation program with sufficient technical, financial, and legal capabilities must be developed to perform selected functions. These functions are essentially actions or activities carried out by various agencies to ensure the adequate performance of a non-central wastewater system.

The management program developed as part of the facilities plan should outline the responsible agency and management technique to be utilized in the community to meet the needs of each of these three stages.

The various responsibilities which should be undertaken to assure adequate on-site management are outlined in Table 4. Of course, the designated agencies must have the legal authorities prescribed by Federal regulations including the right of entry to make inspections and repairs, acceptance of loans, and grants, right to sue and be sued, ability to acquire property, authority to hire consultants and contract for various services, authority to incur debt, issue bonds, levy taxes and assessments, set user charges and permit fees, establish a cost recovery program, and establish service extension policies.

These management functions are described in general below.

Planning, one of the first functions to be performed, involves preparation of a water quality control (and wastewater disposal) plan for the community, indicating the relative suitability and opportunities for on-site alternatives, and more traditional centralized wastewater collection and treatment systems. These plans can be prepared for the entire community as well as specific subareas, such as subdivisions and other development sites. Coordination of agencies and programs is also a part of the planning function. Related planning activities may be undertaken through both the EPA 201 and 208 programs.

System design activities involve the preparation of specifications, drawings, and layouts showing the size and type of system to be used at any given site. The design function is supported by various soil and site feasibility analyses (i.e., site evaluation activities) conducted to gain a better understanding of local conditions and limitations to noncentral system applications. Special plan review and approval procedures are a part of this function also. The review of subdivision plans, for example, is an integral part of the wastewater management planning and design functions.

Inspection during and after installation of on-site and alternative systems is another essential management function. Regulatory mechanisms to ensure proper installation include issuance of a certificate of final inspection, and licensing or registration of system installers.

The performance of routine and emergency maintenance of noncentral systems is a key functional requirement for proper wastewater system operation; however, it is a function that is not widely performed. Operation and maintenance activities can be carried out by a private firm, a public agency, and even the homeowner. Issuance of operating permits, based upon satisfactory completion of routine maintenance procedures, is one common regulatory tool used to encourage homeowners to fulfill this maintenance responsibility. Handling and disposal of septage is another component of the operation and maintenance functions.

## TABLE 4

## SMALL WASTEWATER SYSTEM MANAGEMENT FUNCTIONS

A. Planning

1. Development of water quality management plan
    - Research and development on non-central system costs and performance
    - Integrate land use planning and wastewater management program needs and objectives
2. Coordination of plan preparation, plan review, enforcement and maintenance procedures
    - Coordination among various agencies
    - Public education

B. Site Evaluation and System Design

1. Determination of site limitations for non-central systems
    - Develop procedures and data requirements to conduct site evaluations
2. Develop guidelines for system design
    - Establish performance standards, construction specificaitons, etc.
    - Formulate requirements for licensing, certifying and training system designers
3. Issue permits for system construction
4. Provide design assistance; design publicly owned system

C. Installation

1. Conduct site inspections during system installation
    - Develop procedures and guidelines for installation supervision
    - Establish requirements for licensing, certifying or training system installers
2. Issue permit of final inspection

D. Operation and Maintenance

1. Establish operation and maintenance procedures and responsibilities
    - Conduct periodic inspections and routine maintenance
    - Develop enforcement and regulatory mechanisms, as required
    - Authorize and monitor private sector maintenance contracts
    - Establish emergency maintenance procedures
    - Issue operation permits and renewal reminders

- Establish requirements and programs for licensing, certifying and training system maintainers

2. Develop program for septage handling, treatment and disposal

   - License septage haulers

   - Designate methods and locations of treatment and disposal

3. Identify failing systems

   - Initiate rehabilitation efforts
   - Establish regulatory mechanisms

E. Regulatory/Enforcement Functions

1. Installation permit programs

   a. Continuous inspection program, or
   b. "Spot" checking inspection program

2. Monitoring programs (surface and groundwater quality)

3. Enforcement authority

   a. Injunction
   b. Condemnation
   c. Penalties, fines
   d. Liens on property
   e. Periodic assessments

4. Regulatory liaison

   a. Coordination with other public utilities/regulatory agencies
   b. Reports on operations (system performance, finances)

F. Financing

1. Secure funds for system construction and initial upgrading

2. Set and collect user fees for operation and maintenance

3. Set and collect permit fees

4. Set and collect periodic assessments

G. Public Education

1. Inform public of preventive and emergency maintenance procedures, water and energy conservation measures and methods for public comment

2. Establish system failure reporting systems

System financing involves the application for Federal or state financial assistance to plan, design, and construct alternative wastewater systems. Major sources of financial aid (e.g., PL 95-217) are limited to repair or replacement of existing systems, rather than installation of new systems for private developments or small communities. User charges to cover system operation and maintenance (in the form of service fees and property assessments) are usually set and collected by the management entity.

Water quality monitoring of surface discharges and groundwater near non-central systems is conducted to check compliance with permit requirements, and observe overall system performance.

Public education (informing the public of available waste reduction, water conservation, and routine maintenance procedures) is also an important management function to be considered.

## TYPES OF INSTITUTIONAL ARRANGEMENTS

There are several types of agencies and forms of institutional arrangements available to carry out the wastewater management functions just described. They include:

1. Existing public agencies such as municipalities, counties, states, and soil and water conservation districts.

2. Special service agencies created solely for the purpose of wastewater management, such as special districts, sanitary districts, or public authorities.

3. Private sector entities, such as private contractors, private utilities, rural cooperatives, and property owner associations.

These agencies could be used singly or in combination to implement these wastewater management functions. The purpose of this discussion is to identify a number of institutional options that can be used to manage different types of wastewater systems using individual or small community applications. The authority and administrative structure of a particular management entity varies from community-to-community, and state-to-state; a sample of some of the possible types of institutional approaches to management are described as follows:

1. Municipal Government (such as a Township) -- Local unit of government typically involved in wastewater management, generally possessing a full range of financing powers: revenue and general obligation borrowing, taxation, use of special assessments; as well as regulatory authority, such as zoning, and sewer use ordinances, etc.

2. County Government -- Generally counties have some of the same broad-based authority to operate, finance, and manage sewerage services as a municipal government, and usually cover a much larger geographical area than the municipality.

3. Other Public (Governmental or Quasi-governmental) Agencies -- These include regional planning agencies, regional (multitown or multicounty) boards of health, or other advisory/regulatory entities (excluding special districts or public authorities), as well as state governments and specialized state agencies (e.g., State Department of Health or Environmental Protection.

4. Special District (or Service District) -- An independent unit of government with limited powers to provide services (e.g., water supply and/or sewerage services) to an area within a municipality or county. In terms of wastewater services, a special district's powers are generally parallel to those of a municipality or county. (The extent of these powers is usually precisely defined by state enabling legislation.) Generally, a special district may issue general obligation and revenue bonds, establish rates and charges for services, and levy property taxes. Special districts are usually created to perform specific functions with costs incurred being paid only by those residing within the district. Special districts can appear as sanitary districts, sanitation districts, or utility districts, and can provide single or multiple services.

5. Authority -- One variation of a special district, that is, a special unit of government (or a special purpose type of government) authorized to perform specific functions (e.g., provide water and/or sewerage services). Its jurisdictional coverage is flexible; it can be comprised of a municipality, group of municipalities, county, or group of counties. Its revenues are limited to those derived from its water and sewerage operations, and from Federal or state grants for these purposes. It cannot issue general obligation bonds or levy property taxes like a municipality or special district. (Again, state enabling legislation defines the powers of an authority.)

6. Private (for Profit) -- A sole proprietorship or incorporated business such as septage hauler, plumbing contractor, or private utility formed to provide sewerage services. Private utilities are usually regulated by the state public service or public utility commission.

7. Private (Nonprofit) -- A property owners' association or a privately-owned cooperative can finance and manage sewer services for a specific area. Depending on state legislation, these entities may also be regulated by a public service or public utility commission.

Management programs for alternate systems are evolving in at least three forms:

- On-Site Systems Management Programs (Local or Areawide)
- Small Community Systems Management (Local or Areawide)
- State Regulatory and Guidance Programs

This discussion is oriented towards local management programs (involving the actual operation of either on-site or small community systems), as well as state programs directed at the planning, regulation, and funding of on-site or alternative systems. Local on-site management programs usually provide numerous functions such as system design, installation supervision, and occasionally system operation and maintenance. Both public and private entities can assume administrative and regulatory responsibilities for on-site management. Similarly, small community system programs may involve a public or private entity; these programs are typically oriented toward the actual operation of collection and treatment facilities. Management programs should be designed with regard to specific wastewater collection, treatment, and collection systems. The range of technologies for small communities is broad. (See Table 5.) Given particular site conditions, density of and uses, and other factors, a community may have a combination of systems.

## TABLE 5

## SMALL WASTEWATER TECHNOLOGICAL OPTIONS

A. Collection methods

1. conventional gravity sewers
2. small-diameter gravity sewers
3. pressure sewers
4. vacuum sewers
5. demonstrated hybrid systems

B. Treatment

1. On-site methods

    a. anaerobic units (septic tanks, cesspools)
    b. aerobic units

2. Small area treatment systems (e.g., package plants, multiple home units, ponds, lagoons.

    a. anerobic
    b. aerobic
    c. physical/chemical

C. Disposal

1. On-site methods

    a. conventional soil adsorption systems
    b. sand filter/surface discharge
    c. evapotranspiration techniques

        - natural
        - mechanical
        - combined with soil adsorption system

    d. improved soil adsorption designs and techniques

        - mounds systems
        - evapotranspiration system
        - alternating soil adsorption systems
        - dosing systems
        - soil field rejuvenation with $H_2O_2$

2. Small area

    a. surface
    b. land application
    c. community soil adsorption system

D. Wastewater/water supply flow reduction techniques

TABLE 5 (CONTINUED)

1. generic water consumption/wastewater flow reduction options (low flow, recirculating toilets, composting toilets)
2. generic grey water recycling options
3. accessory water-saving devices

E. Residuals management

1. Treatment

    a. conventional treatment facility
    b. separate septage facility

2. Disposal

    a. hand application
    b. landfill
    c. incineration

State programs related to on-site and alternative systems are very diverse. They range from loosely-structured regulatory programs (i.e., promulgation of design standards) to much more comprehensive facilities planning and technical assistance programs, providing funding for planning and demonstration projects.

## MANAGEMENT DIMENSIONS

The initial assessment of institutional arrangements in selecting a particular management approach is one of the critical steps in formulating an alternative wastewater system management program. The assessment of institutional arrangements should include a discussion of broad management concepts, whose dimensions include:

- Time Frame
- Size
- Purpose
- Authority
- Staging
- Charter

Table 6 displays these management dimensions and their characteristics. This graphic display points out the major components of an assessment of institutional arrangements for a particular area, and helps to highlight the significance of certain management constraints, including service area characteristics, type of wastewater system applied, and scope of management functions. Other characteristics which should be considered in management agency design are outlined in Table 7.

## EVALUATION OF ALTERNATIVES

In evaluating on-site and alternative system options, it is important to consider all viable solutions, and offer a fair assessment of their advantages and disadvantages. Too often, the evaluation of alternatives is incomplete due to one or more of the following conditions:

- True Extent and Cause of Failing Systems Not Identified

- Rehabilitation of Existing Systems Not Given Fair Consideration

- Full Range of Viable Alternatives Not Considered or Understood

- Limitations (or Opportunities) of Site and Planning Area Not Fully Assessed

- A Cluster of Small Systems Viewed as Unmanageable

The consulting professionals, local governments (grant applicants), and state regulatory agencies can all contribute in attempting to avoid such oversights. As on-site and alternative systems prove themselves as viable disposal methods, they will be given more attention in the evaluation of alternatives. The potential advantages in terms of smaller scale, reduced total costs, and simplified operational requirements definitely warrant their consideration.

## TABLE 6. MANAGEMENT AGENCY DIMENSIONS

| Dimensions | Range in Concepts |
|---|---|
| Time Frame | Interim (short-Term) to Permanent (Long-Range) Solutions |
| Size | Single (local Jurisdiction to Multiple Jurisdictional and Countywide Levels |
| Purpose | Single-Function Arrangements to Comprehensive Management Approaches |
| Structure | Extension of Existing Entity Services to New Organization with Specific Management Powers |
| Authority | Planning and Coordination Services to Systems Ownership and Operation |
| Staging | Time-Sequenced Evaluation of Planned Size, Purpose, Authority to the "One-Shot Installation of All Jurisdictions and Powers |
| Charter | Private Arrangements Among Developments/ Developers to Public Government or Special District) Arrangement for Management |

## TABLE 7

## MANAGEMENT CHARACTERISTICS OF SMALL FLOWS INSTITUTIONAL ARRANGEMENTS

A. Type of Management Agency

1. Municipality (including cooperative agreements)
2. County Government
3. Regional planning agency
4. State
5. Soil and water conservation district
6. Special district or service district (single or multiple purpose)
7. Public Authority
8. Private utility/contractor
9. Property Owner's association
10. Rural cooperative

B. Selection of management entity management responsibilities through consideration of:

1. Service area characteristics
    - Land use and population distribtuion
    - Growth prospects
    - Governmental structure
    - Willingness of local agencies to accept new responsibilities
    - Responsiveness of private homeowners to assumer certain responsibilities

2. Type of wastewater system applied
    - Individual versus community
    - Surface versus subsurface disposal
    - Traditional versus innovative

3. Scope of Management Function
    - Short-term or long-term system approach
    - Remedial versus preventive solutions
    - System ownership-system operational responsibilities
    - Regulatory or advisory perspective by management entity

C. Forms of Management Approaches

1. Local Programs
    - Management of on-site systems through site design and evaluation
    - Management of on-site systems through operation and maintenance
    - Small community collection and treatment systems in various types of developmental settings (e.g. lakes, rural developing areas, etc.)

2. State Programs
    - Strong State Programs toward individual and small community systems management
    - Combination state-local participation in the management of individual and small community systems.
    - Strong Local Programs toward individual and small community system management.

Factors other than technology greatly influence the acceptability and implementability of alternative systems (see Table 8). Obviously, technical feasibility and cost are the most visible issues in facilities planning studies, where alternative systems are considered. Technical issues also include how well the system will perform in meeting treatment requirements, and how reliable the system will be to maintain that performance level. Furthermore, the cost issues relate not only to capital cost, but also to long-term operating and maintenance costs and secondary costs (see Table 9).

Although technical issues and initial and annual costs are the major determinants in evaluating system alternatives, the issues of public acceptance and institutional arrangements become more important in the actual implementation of a particular plan (see Tables 10 and 11). This is especially true when considering alternative systems. As alternative technologies have become more established and their total costs have become better defined, the public has gradually accepted these systems, just as they have accepted the more traditional sewerage technologies.

## ISSUES, PROBLEMS, CONSTRAINTS, AND SOLUTIONS

The following are major issues inhibiting the implementation of successful management programs that should be of concern to individuals interested in this concept (applicable management functions are highlighted):

1. Inadequacies in wastewater facilities planning.
2. Deficiencies in legislative authority and intergovernmental conflict regarding the regulation of on-site and small community systems.
3. Lack of a uniform financing policy toward noncentral systems construction and maintenance.
4. Reluctance of the general public to accept noncentral systems technology.
5. Lack of a uniform strategy for operation and maintenance of noncentral wastewater systems.

### Changing Attitudes Toward Wastewater Facilities Planning

The Clean Water Act and subsequent regulations and PRM's outline a number of specific requirements for an approvable noncentral management program. One of the major requirements is the need for a comprehensive wastewater facility plan, which addresses existing wastewater system problems, investigates alternative solutions, and incorporates areawide and local policies regarding land use growth and development. In a small community facility plan the planner or engineer must first identify existing institutional relationships, determine problems, evaluate and select regulatory and operation approaches, examine enabling legislation, and outline an implementation program to secure necessary legislative and organizational changes.

## TABLE 8

## EVALUATION CRITERIA FOR SELECTION OF MANAGEMENT AGENCIES

ADMINISTRATIVE FEASIBILITY (Legal basis, statutory authorization, relative complexity, staff needed, startup time)

INSTITUTIONAL FEASIBILITY (Organization or coordination changes required, existing functional capabilities, general resistance to change)

POLITICAL AND PUBLIC ACCEPTABILITY (attitude toward governmental intervention, local autonomy, availability of grant assistance, cost, public participation in design and administration of the program, accountability, understanding of the problem and need for management, consistency with other plans, policies, and area objectives)

EFFECTIVENESS IN MEETING HEALTH AND ENVIRONMENTAL OBJECTIVES

COST-EFFECTIVENESS

FINANCIAL FEASIBILITY

ECONOMIC EQUITY (COST DISTRIBUTION)

SECONDARY SOCIO-ECONOMIC EFFECTS (extent and distribution)

## TABLE 9

## EVALUATION CRITERIA: EFFECTS

EMPLOYMENT AND ECONOMIC GROWTH (NUMBER AND TYPES OF JOBS)

COST INCIDENCE TO FIRMS-INDUSTRIAL COST RECOVERY

COST AND BENEFIT INCIDENCE TO INDIVIDUALS

PUBLIC FISCAL IMPACTS (DEMAND AND COSTS OF OTHER PUBLIC SERVICES; TAX GENERATION)

RECREATIONAL OPPORTUNITIES

AESTHETIC OR SENSORY QUALITY (AIR POLLUTION, WATER POLLUTION, NOISE)

HISTORIC AND CULTURAL RESOURCES

LAND USE AND HOUSING (GROWTH RATE, DISTRIBUTION, TYPE OF DEVELOPMENT)

SOCIAL INTERACTION (QUALITY OF LIFE, COMMUNITY COHESION)

PUBLIC HEALTH

## TABLE 10

## EVALUATION CRITERIA: POLITICAL AND PUBLIC ACCEPTABILITY

AVAILABILITY OF STATE OR FEDERAL GRANTS TO FINANCE CONSTRUCTION AND/OR OPERATION AND MAINTENANCE

PERCEIVED AS HIGH PRIORITY RELATIVE TO OTHER ENVIRONMENTAL CONTROL STRATEGIES/PROBLEMS

PERCEIVED AS HIGH PRIORITY RELATIVE TO OTHER LOCAL/REGIONAL NEEDS

PUBLIC PARTICIPATION IN THE DESIGN AND ADMINISTRATION OF THE MANAGEMENT PROGRAM (POLITICAL RESPONSIVENESS, ACCOUNTABILITY)

SUFFICIENT VISIBILITY TO INDICATE THAT SOMETHING IS BEING DONE

APPEAR TO BE A REASONABLE APPROACH TO THE PROBLEM

ALLOW FOR LOCAL GOVERNMENTAL INPUT AND DIRECTION (LOCAL AUTONOMY); EXTENT AND NATURE OF INTERGOVERNMENTAL COORDINATION (PRECEDENT REGIONAL ACTION)

EQUITABLE DISTRIBUTION OF DIRECT AND SECONDARY COSTS AND BENEFITS (GEOGRAPHICALLY, AMONG INCOME/SOCIAL GROUPS, BETWEEN PUBLIC/PRIVATE SECTORS)

GENERAL ATTITUDES RELATIVE TO EXTENT/NATURE OF GOVERNMENTAL CONTROL; LEGITIMATE PUBLIC PURPOSES OR OBJECTIVES

LOCAL POLITICAL AND PUBLIC SUPPORT (ANTI-GOVERNMENT SENTIMENT IN RURAL AREAS: RESISTANCE TO CHANGE; DESIRE LIMIT GROWTH; RECOGNITION OF PROBLEM AND ON-GOING COMMITMENT TO MANAGEMENT)

CONSISTENCY WITH 201, 208, AND OTHER PLANS

These various activities should be undertaken to assure that the completed wastewater facilities plan become usable, accurate, and locally-acceptable guidance to developing wastewater management policies and programs for the community. Several statewide and areawide 208 planning agencies (as mentioned earlier) have recognized the critical role of the wastewater facilities plan as a basis for developing community wastewater management programs.

In conjunction with the increased emphasis on the wastewater facility plan, adjustments to statewide plan review procedures are being considered in several states. Illinois, for example, has recently created an Innovation and Alternative Design Review Panel represented by numerous departments of the State Water Pollution Control and Health Agencies. California has created an Alternative Systems Unit to specifically review small community facility plans. Within the past few months, New Hampshire has designated one individual within the state's water pollution control agency as a small community assistance representative. The California and New Hampshire experiences illustrate the recognition, on the part of these states, that an individual or group of "experts" in facility plan preparation and federal funding policies are necessary to implement noncentral wastewater management programs.

## State -Local Conflicts Regarding Noncentral System Regulation

The successful experience of management programs rests largely upon their ability to enforce uniform design standards and site evaluation requirements. The enforcement responsibility is often shared between state and local governments, which occasionally results in jurisdictional conflicts and time delays in issuing permit approvals. A frequent problem that arises under this shared arrangement is that an individual or a community may attempt to satisfy two or more regulatory agencies desiring different outcomes in order to obtain permit approval.

A growing concern in states where regulatory responsibilities are shared between state and local government is the lack of explicit interagency or intergovernmental agreements which outline the responsibilities of the state and local regulatory bodies. The resulting confusion and conflict in enforcing regulations has in the State of Washington, for example, prompted several sessions of the State House Committee on Ecology to review current regulatory responsibilities and administrative practices.

Other states in similar situations have consolidated multiple agency responsibilities in water pollution control. After the USEPA was created, many states reorganized to centralize state water resource management responsibilities. Effective water resources management (and in this case, the management of on-site and small community systems) can be provided through an integrated coordinated process which recognizes available expertise at various levels of government.

## Lack of a Uniform Federal Financing Policy

The USEPA, through Federal legislation and PRM's has developed cost-effectiveness guidelines to be applied in reviewing and selecting alternative wastewater management technologies for small communities. The standard procedure for the USEPA is to provide grant assistance to only the most cost-effective alternative (based on a thorough analysis of community need and alternative choices). As mentioned earlier, however, there are several grant assistance programs available through the Federal government (e.g., EPA and FmHA). In addition, states may also have parallel grant assistance programs (in the form of grants, loans, tax supports, or other transfer payments) that can be applied to implement wastewater management projects.

Under this situation, an individual with favorable "grantsmanship" skills could develop a financial package (of Federal and state revenues) to implement projects which are not the most cost-effective in the USEPA analysis. Thus, the cost-effectiveness of different alternatives can be ignored through various means of financing which may result in low cost to the homeowner even with a project which is more costly than some of the alternatives investigated. Community preferences for traditional technologies (e.g., gravity sewers and a standard treatment plant) obviously contribute to this situation, and are common occurrences in small communities.

On-site management arrangements have proven to be cost-effective solutions to wastewater needs in a number of communities. In some facility plans, however, true costs of conventional systems are biased to the disfavor of on-site systems (e.g., unrealistic O&M cost estimates, omission of collection system costs).

Obviously, it is essential to meaningful cost-effective analysis that the full costs of both on-site as well as conventional systems are accurately portrayed.

Costs of on-site and alternative systems which should be estimated include the following: capital costs for new installations, repair or replacement of present treatment, collection, and disposal systems for effluent and residuals (septage/sludge), including eligible land and equipment; estimated annual cost for repair and replacement of systems; annual cost of pumping and other maintenance activities; and the costs of plan reviews, installation inspections, O&M inspections, groundwater monitoring, and other regulatory/enforcement activities. Some of these costs will be borne by the public sector while other costs will be borne by homeowners. Expected revenues from user charges, permit fees, general revenues, taxes, assessments, cost recovery, bonds and other sources should be estimated.

A uniform, consistent policy toward determining cost-effectiveness and financing small community projects is needed. The "White House Rural Development Initiatives" represents an attempt by the Federal government to coordinate the numerous agencies involved in financing small community wastewater management projects, through a series of interagency agreements. For example, through this cooperative effort by Federal agencies, development of common criteria for conducting cost-effectiveness analysis and coordination procedures for interagency facility plan review has been proposed. Should such a program be implemented at the Federal and state level, low-cost technologies may be given greater consideration in small towns and rural areas.

## Public Attitudes Toward Noncentral System Technology

The key to the success of a wastewater management program is public acceptance of the applied sewerage technology. In dealing with non-conventional approaches to wastewater management, it is very important to educate the public and explain the service being provided. In most cases, it is necessary to convince service area residents that the proposed system is feasible, applicable, and necessary.

The job of disseminating information about available technologies is shared by agencies such as the National Sanitation Foundation, USEPA, FmHA, National Association of Homebuilders, and the Alternative Wastewater Management Association (AWMA) at the national level, as well as state and local entities.

The most effective means of disseminating information and raising public awareness concerning the applicability of low-cost technologies is through implementation of projects in small community and rural situations.

Projects such as these which have been implemented, are a result of Federal, state, and local cooperation and interaction. Despite the participation of many agencies in organizing these demonstration programs, it is the local agency (e.g., the county or town health department, special management district, or utility) which provides the necessary one-to-one interaction with the service area resident. The visibility and performance of the local representative is a key ingredient to developing, initiating, and operating a successful management program. In most instances, the local representative is a necessary component of the management program.

## Establishing Operation and Maintenance Programs - A Frequently Overlooked Management Function

The poor performance of on-site systems in the past may have resulted from inadequate maintenance, design, and/or installation. Typical management programs concentrate on enforcing regulations dealing with site evaluation, system design, and installation supervision leaving system operation and maintenance to the homeowner. Proper maintenance of on-site and small community systems can be provided through a variety of methods, depending on the willingness of the local government and general public to accept this responsibility. Shifting the responsibility of providing periodic system maintenance from the homeowner to the public sector has been suggested as a solution; however, there are several problems associated with this approach:

1. Voluntary approaches to periodic maintenance of systems by homeowners may not ensure that work is actually being accomplished.

2. Public maintenance of systems through organized maintenance districts may be unpopular because it involves another function to be performed by local governments.

3. Contracting with private septage haulers is a possibility; however, some controls are necessary to ensure that an adequate and fair service is being provided.

4. Inspection of system operation requires routine surveillance of the system with limited spot-checking and testing of system performance. Relying totally on complaints or references of system malfunction by neighbors or community residents, usually is not an effective approach. Some form of scheduled inspection or maintenance is usually required.

Many of the existing wastewater management programs, particularly those using on-site systems, continue to place maintenance responsibilities on the homeowner. In fact, even on-site management programs, such as in Georgetown Divide Public Utility District, California, the homeowner owns the on-site system and is consequently responsible for repairing or replacing the system should a malfunction occur. The service charge levied by the district provides necessary funds to perform periodic maintenance and inspection of system operation.

The issue of system ownership and liability for repair or replacement is a key concern to be addressed when organizing a management program. Typically, the long-term satisfactory performance of an on-site system is difficult to guarantee. On-site management programs have elected to leave the burden of system repair/replacement with the homeowner. Some private septic tank installers and cleaners are evaluating the feasibility of offering maintenance services to individual homeowners on a contract basis.

## IMPLEMENTATION OF RECOMMENDED MANAGEMENT APPROACH

This paper is addressed particularly to small communities participating in EPA's 201 Construction Grant Program. These communities are required by the Clean Water Act and subsequent regulations to do a thorough analysis of technological options and to develop a management program to assure proper system operation. The issues and alternatives discussed in this paper should assist communities in designing their management programs. This information should also be of assistance to other communities desiring to improve management of on-site and alternative systems although not participating in the 201 program.

The community must make a number of choices regarding the scope of services, assignment of responsibilities, regulatory techniques, and financial mechanisms in designing its management program. Most of these decisions should be made during the facility design process. Where appropriate, interagency agreements should also be negotiated at this time. In making its management decisions, some analysis of current legislation and institutional arrangements is necessary in order to determine the parameters of choice. A highly participatory process will be necessary to assure implementability. The areawide and State 208 water quality management agencies may be able to assist the community in better understanding management options.

Depending upon the approach selected, new or modified State legislation, local ordinances, and regulations may be necessary to implement the management program. Where appropriate, the community may wish to enlist the assistance of other agencies in drafting or obtaining support for necessary legislation. Other start-up activities will include staffing, procurement of equipment and office space, and detailed design and implementation of regulatory, billing, monitoring, certification, training, and public education programs. Although these costs are not generally eligible for funding under the 201 Program, some assistance may be available through the 208 Water Quality Management Program.

State agencies should take the following actions to improve the effectiveness of the on-site and small communities program: (1) review construction grants priority system to reflect small community needs, (2) educate project reviewers regarding small system management and technology options to facilitate handling of facility plans, (3) review relevant design and installation standards and regulations, (4) clarify state/local responsibilities, (5) review state enabling legislation and propose amendments as necessary (i.e., on-site districts, certification programs for installers, inspectors, and pumper/haulers), (6) provide technical assistance and guidance to engineering consultants and local officials regarding small systems management (e.g., model codes, cost-estimating guides, suggested public participation practices, assistance in preparing applications). States vary considerably in their direct responsibilities for plan reviews, site evaluations, inspections, enforcement, and monitoring activities. These functions are generally shared or delegated to local units of government. Recommended state activities to encourage implementation of small community wastewater management programs are outlined in Tables 12 and 13.

## Conclusion

On-site and small community management programs have proven to be cost-effective and viable solutions to wastewater needs in a number of communities across the nation. Implementing this type of wastewater management program is a difficult task in most communities, largely due to the following issues:

1. Unwillingness of the public to accept noncentral system technology.
2. Difficulties in properly enforcing regulations concerning noncentral system siting, design, and operation.
3. Legislative deficiencies inhibiting the initiation of management programs.

These issues are not independent, but interrelated due to the participation of numerous agencies at national, state, regional, and local levels in carrying out various management functions. These constraints can be overcome through:

1. Better cooperation among participating agencies.
2. Documentation of existing management program performance costs and effectiveness.
3. Education of project reviewers, site evaluators, system designers, and consumers.
4. Clarification of state/local responsibilities.
5. Adoption of state enabling legislation for creation of noncentral wastewater management districts.
6. Development of mechanisms to improve the delivery of Federal and state rural wastewater management programs through model codes,

## TABLE 12

## RECOMMENDED STATE ACTION

1. REVIEW REGULATIONS REGARDING APPROVAL, DESIGN, AND INSTALLATION OF CONVENTIONAL AND INNOVATIVE AND SMALL FLOWS SYSTEMS.

    A. CLARIFY STATE/LOCAL RESPONSIBILITIES FOR REVIEW AND APPROVAL OF PLANS AND STANDARDS SETTING,

    B. IMPROVE REQUIREMENTS REGARDING SOIL SUITABILITY DETERMINATIONS

    C. MAKE REGULATIONS PERFORMANCE ORIENTED; FACILITATE UTILIZATION OF APPROPRIATE INNOVATIVE TREATMENT, COLLECTION, AND DISPOSAL METHODS.

2. COORDINATE WITH AREAWIDE AND STATE NONDESIGNATED 208 PLANNING EFFORTS REGARDING ON-SITE PROBLEM ANALYSIS AND POLICY RECOMMENDATIONS.

3. REVIEW STATE ENABLING LEGISLATION AND PROPOSE AMMENDMENTS AS NECESSARY TO FACILITATE ALTERNATIVE LOCAL MANAGEMENT ARRANGEMENTS.

4. PROVIDE TECHNICAL ASSISTANCE AND GUIDANCE AS APPROPRIATE TO ENGINEERING CONSULTANTS AND LOCAL OFFICIALS REGARDING CONSIDERATION OF SMALL FLOWS SYSTEMS AND INSTITUTIONAL ALTERNATIVES (STATE POLICY, ISSUANCES, MODEL ORDINANCES, ASSISTANCE IN PREPARING APPLICATIONS, PARTICIPATION IN MANAGEMENT ENTITY ORGANIZATION MEETINGS).

## TABLE 13

## STATE IMPLEMENTATION PROCEDURES FOR ALTERNATIVE SYSTEMS MANAGEMENT

MODEL STATE ENABLING LEGISLATION

MODEL LOCAL SANITARY CODES, BASED ON THE ENABLING LEGISLATION (AND WITH SUGGESTED MODIFICATIONS FOR SOME STATE SITUATIONS)

COST-ESTIMATING GUIDES FOR MANAGEMENT ALTERNATIVES

LANGUAGE TO BE INSERTED INTO LOCAL SANITARY CODES, HEALTH CODES, ZONING, OR OTHER EXISTING REGULATIONS

GUIDELINES FOR CHOOSING MANAGEMENT ALTERNATIVES, AND THE RELEVANT STEPS IN THE PLANNING PROCESS

PROCEDURES FOR USE IN DEFINING EXISTING OR POTENTIAL PROBLEMS REQUIRING MANAGEMENT, AND FOR IDENTIFYING APPROPRIATE MANAGEMENT ALTERNATIVES

SUGGESTIONS ON PUBLIC PARTICIPATION PROCEDURES TO BE USED

SUGGESTED INTERFACES WITH THE 208 PROGRAM, AND WITH CONSTRUCTION GRANTS FUNDING

It is hoped that a large number of communities across the country will be able to meet their wastewater needs through improved management of existing and upgraded on-site and small community wastewater systems. It remains to be seen how many communities will participate directly in the Federal grants program to meet their needs. States and EPA regional offices are attempting to streamline grant and facility review procedures in order to provide assistance in a more timely fashion.

Local governments are becoming interested in applying noncentral wastewater system technologies to existing systems and developing areas. Even so, in view of the large needs, it is unlikely that all communities will be able to be assisted in the near future. In the meantime, the states and the communities themselves can do much to alleviate their wastewater problems at low cost through the adoption of some of the management approaches discussed in this presentation.

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# "INSTITUTIONAL CONSIDERATIONS IN IMPLEMENTING ON-SITE AND SMALL COMMUNITY WASTEWATER MANAGEMENT PROGRAMS"

Edited Questions and Answers Following This
Presentation
by
Don C. Niehus
USEPA-MERL

AUDIENCE: If you have all these septic tanks and the ground water quality has been fairly acceptable in the past, then septic tank systems as an alternative to the centralized system are going to pollute ground water quality.

MR. NIEHUS: It could. That's why our regulations require that we monitor performance.

AUDIENCE: But the studies that have been made indicate that most of the ground water pollution or surface water pollution problems probably come from sources other than septic tanks. Whereas the pollution from septic tank systems or what have you, are minor details.

MR. NIEHUS: One study being done by Urban Systems looked at the types of documentation of the problems that went into the consideration of alternative systems, and I think it's consistent with what we were saying that where they could document the ground water pollution problems, a large percentage was due to a source other than the septic tank itself. I'm sure you could find examples where the opposite is true.

AUDIENCE: I wonder if there are pockets of problems, groups of people who are interested in getting this individual system, and they have to apply through a government agency essentially, if it'll be necessary in all cases that some sort of an agency be set up in order to obtain a grant for these people. What is the level of management or government regulation within the area that's going to be necessary in order to obtain the funds for individuals?

MR. NIEHUS: We're in no way suggesting that a special agency with all these responsibilities that I outlined earlier has to be established. There are certain minimum tasks that the designated agency must perform. That's pretty clearly spelled out in the regulations. It can be just the agency that is the lead agency and filing on behalf of the private owners, but that agency does have to accept responsibility for problems and monitoring the system, and also for assuring that there will be sufficient revenues generated to pay for the maintenance and operation of the system.

Whether or not the agencies that are presently available in that particular community either have the authority or have an inclination to accept the responsibility is the question, but it must demonstrate to the state and to the community that it does have authority and intends to carry out the responsibility.

AUDIENCE: It seems to me what you're saying is that if some group of people, say even a small group petition their town government to apply in their behalf, the town government's planning effort could not be scoped just to those petitioners, and you would have to essentially set up some sort of plan that would look to the whole political jurisdiction.

MR. NIEHUS: You have to have an overview of what the needs are in the whole service area, but that doesn't imply that whole service areas have to be serviced.

AUDIENCE: I think there is something wrong here. You are mixing regulatory and operations functions there. I just don't agree that you can list all of those functions under one management entity.

MR. NIEHUS: What we would say to that is that functions that we are listing here do not necessarily have to be done in total by one entity. All these functions must be done by somebody. The quesiton is, who is going to do what and at what level, and how these functions relate to each other.

For example, at present, the health departments in most states, at the local level, are the ones that have the prime responsibilities for regulations. Previously, the homeowner has the basic responsibility for maintaining a system; obviously, there is a problem with that.

Not too many people would suggest that the health deaprtment be the appropriate agency to operate the system, so it might be a special district or it could be a sanitary district, with the regulatory function remaining with the health department or some other entity. There are many combinations there that are possible here, so I think that we need to understand what are the institutional relationships here and who would be the appropriate person to tackle which specific task.

AUDIENCE: One thing I would like to mention with regard to user charges and I have been through an awful lot of discussions with local people and state agencies concerning user charges, is that anytime you start charging a user in a district or city a different charge than you charge another user, regardless of what type of treatment, whether he is on a different system in fact, you get in trouble. That is understandable because the local political people who are ultimately responsible for the charges instituted in their locality get the pressure. Consequently, it has been found, at least in our area, that if you can determine your total annual cost and distribute those proportionately based upon use among all the users, then you have a better situation.